THE OHIO JOURNAL OF SCIENCE

VOLUME XLI — 1941

LAURENCE H. SNYDER, Editor-in-Chief

PUBLISHED AT COLUMBUS, OHIO, BY THE

OHIO STATE UNIVERSITY

and the

OHIO ACADEMY OF SCIENCE

THE OHIO JOURNAL OF SCIENCE

ADMINISTRATIVE BOARD

For Ohio State University	For Ohio Academy of Science
F. C. Blake	F. E. Ray
E. N. Transeau	J. R. Patrick

EDITORIAL STAFF

Laurence H. Snyder ..... Editor in Chief
Glenn W. Blaydes ..... Associate Editor
Bernard S. Meyer ..... Business Manager
John A. Miller ..... Associate Business Manager

J. B. Park ..... Agronomy	J. Ernest Carman ..... Geology
R. A. Knouff ..... Anatomy	W. H. Shideler ..... Paleontology
H. H. M. Bowman ..... Botany	C. W. Jarvis ..... Physics
R. C. Burrell ..... Chemistry	F. A. Hitchcock ..... Physiology
E. Lucy Braun ..... Ecology	J. P. Porter ..... Psychology
F. C. Waite ..... Embryology	E. R. Hayhurst ..... Public Health
G. D. Hubbard ..... Geography	R. V. Bangham ..... Zoology

THE OHIO JOURNAL OF SCIENCE

Is published jointly by the Ohio State University and the Ohio Academy of Science.

TABLE OF CONTENTS

NUMBER 1—JANUARY

PAGE

Quantitative Plankton Studies of Turkeyfoot Lake, Near Akron, Ohio, *Walter C. Kraatz* 1

Sebekia oxycephala (Pentastomida) from Florida Fishes and Some Notes on the Morphology of the Larvae. . *Carl Ernest Venard and Ralph V. Bangham* 23

The Alimentary Tract of *Vespula maculifrons* Buy. (Hymenoptera: Vespidae) ..... *Robert Thomas Mitchell* 29

Quantitative Determination of Rhythmicity in Organisms ..... *Orlando Park* 39

Presence of the *Ligamentum botalli* in the Golden Eagle *Aquila chrysaëtos* (L.), the Red-tailed Hawk *Buteo borealis borealis* (Gmelin), and the Common Pigeon *Columba livia* (L.) ..... *Fred H. Glenny* 46

Book Notices 22, 28, 45, 49, 50

NUMBER 2—MARCH

The Generic and Specific Status of Four Ohio Spiders of the Genus Agelenopsis ..... *Paul J. Seyler* 51

The Sensitivity of Anemometer Cups ..... *John G. Albright and G. E. Klein* 70

Butomus umbellatus in America ..... *Earl L. Core* 79

A New Genus (Knullana) and Two New Species of Leafhoppers (Homoptera-Cicadellidae) from Mexico ..... *Dwight M. DeLong* 86

Studies in Human Inheritance XX. Four Sets of Alleles Tested for Incomplete Sex Linkage ..... *Laurence H. Snyder* 89

The Distribution of *Cambarus sloani* Bundy, in Ohio ..... *Rendell Rhoades* 93

A Systematic Study of the Main Arteries in the Region of the Heart—Aves. II. (*Crotophaga ani*), (*Saurothera merlini*), and (*Coccyzus americanus*) ..... *Fred H. Glenny* 99

Book Notices 101–102

NUMBER 3—MAY

Presidential Address—A Present Day Examination of the Postulates of John Dalton ..... *Wm. Lloyd Evans* 105

Research on the Central Auditory Mechanisms: Some Recent Methods and Results ..... *E. A. Culler* 117

Some Social Aspects of Deafness ..... *E. R. Abernathy* 123

The Development of High Voltage for the Production of Neutrons and Artificial Radioactivity ..... *E. U. Condon, Ph.D.* 131

A Comparative Study of Neutron- and X-Radiation upon Biological Tissues in the Cancer Problem ..... *Isadore Lampe, M.D.* 135

Cancer: Clinical and Experimental Aspects ..... *Francis Carter Wood, M.D.* 139

The Classification of Nerve Fibers ..... *Herbert S. Gasser* 145

The Interaction of Neurones ..... *R. W. Gerard* 160

Encephalization of Motor Functions During the Evolution of the Primate Nervous System ..... *J. F. Fulton, M.D.* 173

A Scaled Model of a Proposed Protein Structure ..... *Edward Mack, Jr.* 183

Ecological Factors and Drosophila Speciation ..... *Warren P. Spencer* 190

The Origin of Ohio Soils ..... *Guy W. Conrey* 201

PAGE

Prehistoric Factors in the Development of the Vegetation of Ohio, *Edgar Nelson Transeau* 207

The Aerial Traverse. An Application of Aerial Photography to Geographic Studies..... *John L. Rich* 212

Postglacial Vegetation in the Erie-Ohio Area..... *Paul B. Sears* 225

The Differentiation of the Deciduous Forest of the Eastern United States, *E. Lucy Braun* 235

Recent Trends in Horticultural Research..... *J. H. Gourley* 242

Professor John Henry Schaffner..... *Adolph E. Waller* 253

Book Notices..... 134, 138, 144, 159, 172, 200, 206, 211, 241, 250

NUMBER 4—JULY

The Ohio Academy of Science (Mostly Historical)..... *William H. Alexander* 288

The Saga of Paddy's Run..... *Stephen R. Williams* 313

Additions to the Revised Catalogue of Ohio Vascular Plants. IX, *Clyde H. Jones* 328

Book Notices..... 327, 345, 346

NUMBER 5—SEPTEMBER

The Heart and the Red Blood Cells as Generator and Distributors of Static Electricity, *George Crile, M.D., Otto Glasser, Ph.D., and Daniel P. Quiring, Ph.D.* 347

Inexpensive Equipment for the Preparation and Concentration of Pure D_2O or of Deuterium-Rich Water. Description of Construction and Operation of the Former Ohio State University Heavy Water Plant, *Herrick L. Johnston and W. Heinlen Hall* 357

The Geography of the Bellevue Area..... *Ruth Rockwood Daugherty* 366

Black Widow Spider (*Latrodectus mactans* Fab.) Distribution in Ohio, *Frank Merrick Semans* 380

Nine New Coleoptera—(Plastoceridae, Buprestidae and Cerambycidae), *Josef N. Knull* 381

Hydrogen-ion Concentration and the Initiation of Growth.... *Cyril J. Corum* 389

Book Notices..... 356, 365, 379, 388

NUMBER 6—NOVEMBER

Annual Report of the Ohio Academy of Science, 1941..... 397

A Preliminary Survey of Mexican Psyllidae (Homoptera).... *John S. Caldwell* 418

Studies in Antibiosis Between Bacteria and Fungi. II. Species of Actinomyces Inhibiting the Growth of *Colletotrichum gloeosporioides* Penz. in Culture..... *Const. J. Alexopoulos* 425

The Physiological Activity of Certain Alcohols and Ethers to Goldfish, *Harvey C. Brill and Alexander K. Presnell* 431

Parasites from Fish of Buckeye Lake, Ohio..... *Ralph V. Bangham* 441

Relation of Sauger Catch to Turbidity in Lake Erie..... *Kenneth H. Doan* 449

Supplementary Note on the Effect of the 1938 Hurricane..... *Mary D. Rogick* 453

Protozoan Parasites of the Orthoptera, with Special Reference to Those of Ohio. III. Protozoan Parasites in Relation to the Host and to Host Ecology..... *Frank Merrick Semans* 457

Book Notices..... 424, 440, 464

Index to Volume..... 465

THE OHIO JOURNAL OF SCIENCE

VOL. XLI JANUARY, 1941 No. 1

QUANTITATIVE PLANKTON STUDIES OF TURKEYFOOT LAKE, NEAR AKRON, OHIO

WALTER C. KRAATZ,
Department of Biology, University of Akron,
Akron, Ohio

INTRODUCTION

Turkeyfoot Lake is the southernmost of a chain of lakes and reservoirs known as the Portage Lakes, partly within but mostly south of the city of Akron. The three lakes farthest south, with connecting channels, all on one level higher than the other lakes, are shown on the accompanying map (Figure 1).

An entirely new reservoir, Nimisila, is in the process of filling up. It will have its outlet into the southern end of Turkeyfoot.

Turkeyfoot has an arm northwest called Rex Lake and a more broadly connected eastern lobe, Mud Lake, and the rest of it is partly divided into lobes. In the large, central southern lobe, collections were made in a central area having a depth of 13 to 14½ meters, maybe more at some places. The collecting station is marked "X." Besides plankton collections, bottom samples were made with Ekman dredge, but bottom organisms are not reported in this paper. One central station has been found adequate in some recent work (Ricker, 1938) for pelagic limnoplankton.

Near the entrance of Mud Lake into Turkeyfoot, marked "Y" on the map, collections were also made at two stations, both shallow, differing somewhat in nature of bottom, but these are not reported in this paper.

The aims were to show seasonal and vertical distribution of the chief plankton organisms. Temperature records and chemical tests of dissolved O_2, dissolved CO_2 and pH were made. No extensive limnological or ecological studies were possible in the limited time available.

EDUCATION LIBRARY

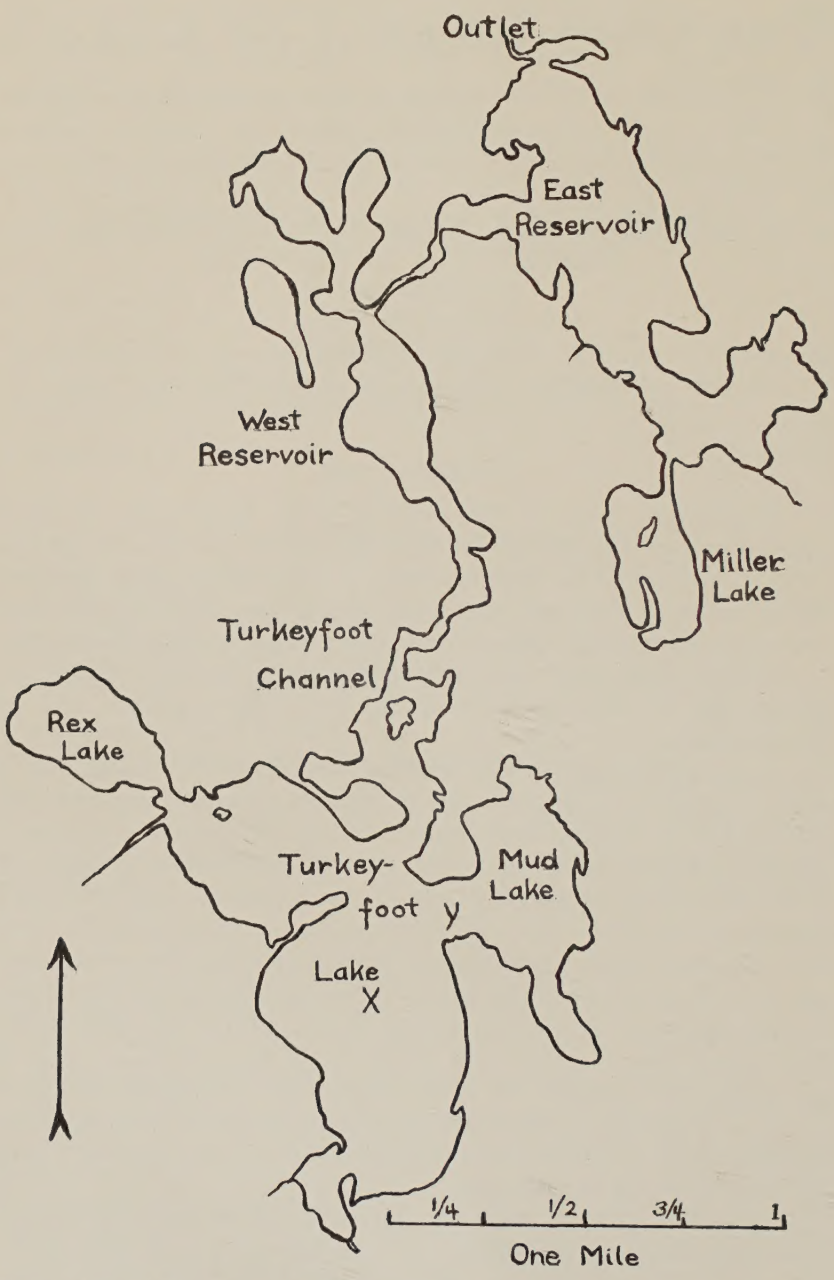


Fig. 1. Map of East Reservoir, West Reservoir and Turkeyfoot Lakes, and smaller Ponds and Lakes. Roads, bridges, etc., are omitted. Copied from a map of the Ohio Division of Conservation.

Very little has been published on these lakes, though much uncorrelated collecting has been done. One paper on net-plankton of East and West Reservoirs appeared (Kraatz, 1931). Recently a paper (Kraatz, 1940) which is part of this same study, appeared, serving as an introduction to the present paper.

ACKNOWLEDGMENTS

The Division of Conservation of Ohio donated a Foerst plankton trap, Kemmerer-Foerst water bottle and also an Ekman dredge; without this equipment the work would have been impossible. Particular thanks are due to Mr. E. L. Wickliff for securing this equipment and encouraging the work. At the beginning of this work Mr. Lee S. Roach demonstrated the collecting and laboratory methods as done in the state conservation work. Chemical tests were performed by Miss Eleanor Mueller and later by Mr. Samuel Caplin. On each collecting trip some student assistant or other student helped with the apparatus and collection. Mr. Walter K. Harris, Portage Lakes Conservation Officer, gave generously of his time, running the state motor boat on all trips, without which the collection would have been impossible.

Dr. L. H. Tiffany, and after his leaving Ohio, Dr. C. E. Taft, identified some algae and Dr. L. E. Noland, some Protozoa. The extent of their examination of various types of organisms is hardly realized in this paper, where only the main plankters appear. Mr. Bill J. Barkley copied the graphs in presentable form.

Microscopes, counting cells, and all chemical and other materials, and also the deep sea thermometer and Foerst centrifuge belong to the Biology Department, University of Akron.

PLANKTON COLLECTING AND LABORATORY METHODS

Collections were made monthly at a convenient time, usually on a Saturday, from about the 15th to the 20th of the month, starting in August, 1936. None were secured in December, 1936, or February, 1937; thin ice proved unsafe for walking to the collecting station, but too thick for the boat to get through. A small collection was made from the boat January, 1937. Collections continued from March through October, 1937. November, 1937, was unavoidably missed. On December 4 a small collection was made through rather thin ice, but only at the shallow Mud Lake station. In January, 1938, a collection unfortunately incomplete, was made through thick ice; in February, an incomplete one from boat; but complete collections from

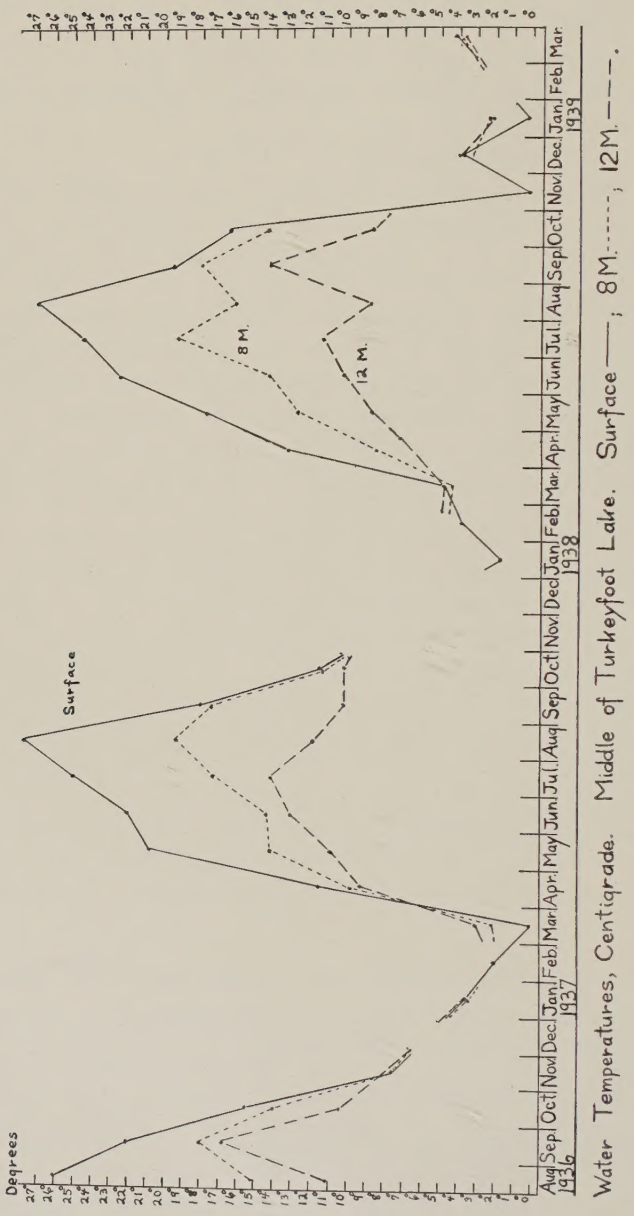

Degrees
Surface
8 M.
12 M.
Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar
1936 1937 1938 1939
Water Temperatures, Centigrade. Middle of Turkeyfoot Lake. Surface ——; 8M.------; 12M.— — —.

Fig. 2. Water Temperatures of Turkeyfoot Lake.

March onward. Circumstances again prevented a November collection, but an early December collection was made from a boat. A collection through ice was made January, 1939; none was possible due to weather conditions in February, but a final collection was made in March.

Methods of collecting have been adequately given in the paper referred to above (Kraatz, 1940) and likewise laboratory methods explained. The main aim of the paper was to compare the number of organisms per liter of lake water as secured by the trap concentrated by its net, with those secured by the water bottle, concentrated by the centrifuge. It was shown that for organisms falling within the general scope of netplankton, generally the trap was better, largely because, having a much larger initial sample and more concentrated laboratory vial sample and counting cell sample, much larger numbers of organisms were actually counted and less multiplying required to get organisms per liter, than in the case of the water bottle samples. It was shown that certain kinds of blue-green algae of low specific gravity were lost in centrifuging. But it was also seen that most kinds of diatoms were collected often in significantly larger numbers with the water bottle. The organisms per liter of net and centrifuge plankton in neighboring columns for all collections were studied and discrepancies compared as to their significance. Usually it was possible to determine for kinds or groups of organisms which technique was best. The selection is shown in the table and discussion later in this paper.

TEMPERATURE RECORD

A deep-sea reversing thermometer (H. B. Instrument Co.) was used from March, 1937, on. Previously an ordinary chemical thermometer was used by hurriedly placing it immediately after collection into the jar holding water from the brass water bottle as collected from just under surface, at 4 m., 8 m., and 12 m. These were the water samples later used for centrifuging. From August, 1936, to June, 1937, inclusive, records are available only for these four levels, but from July, 1937, to March, 1939, records were made at meter intervals. In certain winter months no records were secured from the middle of the lake.

The accompanying table shows the Turkeyfoot station "X" record, in centigrade for period in which meter interval readings were taken. The graph shows for the entire collecting period, the surface record, 8 m., and 12 m. records; the 4 m. curve very close to and slightly below the surface curve was not included because it would add to the confusion of lines. (See Table I and Fig. 2.)

It should be noted that the only temperature readings below ice from the middle of Turkeyfoot were January, 1938, (unfortunately only a surface reading) and January, 1939. Record marked * was close to shore at south end of lake; it was impossible to get out to the middle of the lake. One temperature record of surface water, March, 1937, was slightly below 0° C. The surface was not ice-covered; it was very windy and air temperatures below freezing. One temperature reading below ice in Mud Lake (station D) December, 1937, was 2.3° C.

TABLE I

WATER TEMPERATURE, DEGREES CENTIGRADE, MIDDLE TURKEYFOOT LAKE

	July 19, 1937	Aug. 20, 1937	Sept. 18, 1937	Oct. 16, 1937	Nov. 20, 1937	Dec. 4, 1937	Jan. 15, 1938	Feb. 19, 1938	Mar. 19, 1938	April 16, 1938	May 21, 1938	June 18, 1938	July 16, 1938	Aug. 20, 1938	Sept. 17, 1938	Oct. 15, 1938	Nov. 26, 1938	Dec. 3, 1938	Jan. 28, 1939	Feb. 25, 1939	Mar. 25, 1939
Surface	25.0	27.6	17.7	11.6			1.8	3.8	4.7	13.2	17.7	22.4	24.5	27.1	19.6	16.5	0.4	3.6	0.2		4.6
1 m	24.8	27.2	16.9	11.8					4.7	11.8	17.7	22.4	24.4	26.5	20.2	15.8		3.6	1.8		4.4
2 m	24.5	27.1	17.4	11.6					4.4	11.6	17.7	22.4	24.4	26.4	20.2	15.6		3.6	2.0		4.4
3 m	24.4	26.8	17.5	11.6					4.4	10.9	17.6	22.2	24.3	26.2	21.0	15.6		3.6	2.2		4.4
4 m	24.0	25.2	17.4	11.5					4.8	10.4	16.6	22.0	24.3	26.0	20.6	15.5		3.4	2.2		4.3
5 m	22.1	22.7	17.0	11.5					4.8	10.2	15.6	20.2	24.4	24.0	20.6	15.4		3.4	2.2		4.4
6 m	20.6	21.5	17.4	11.5					4.4	9.7	15.6	20.1	23.0	22.5	20.6	15.0		3.4	2.2		4.0
7 m	19.2	19.2	17.4	11.4					4.4	9.1	14.5	17.0	21.1	18.8	20.2	14.6		3.3	2.3		4.0
8 m	17.3	19.4	17.4	11.4					4.4	8.5	12.9	14.4	19.4	16.2	18.0	14.4		3.3	2.3		4.0
9 m	17.0	14.8	14.7	11.2					4.3	8.0	12.1	9.6	16.3	15.5	16.0	13.8		3.3	2.4		4.0
10 m	14.6	12.3	12.4	11.2					4.2	8.0	9.8	9.9	10.4	12.9	15.4	11.6		3.4	2.4		4.0
11 m	14.4	11.6	10.3	10.8					4.6	7.4	8.7	8.2	9.4	9.8	14.8	10.4		3.4	2.6		3.9
12 m	14.1	11.8	10.2	10.2					4.6	7.1	8.6	10.2	11.4	8.8	14.4	8.6		3.8	2.2		3.9
13 m	12.0	11.8	*	9.1					4.6	6.4	7.9	8.3	12.1	8.0	9.8	8.8		3.8	2.5		3.8
14 m	11.8	10.4	*	*					*	*	7.5	7.8	11.4	8.8	*	8.7		3.8	*		3.8
15 m	11.0	10.2	*	*					*	*	*	*	*	*	*	*		*	*		*

Off shore at Kelper's landing

Close similarity in seasonal temperature changes is shown in the two and one-half years of temperature curves. A series of spring and fall readings practically uniform from top to bottom indicates clear cut spring and fall overturns. No real thermocline can be noticed, however.

CHEMICAL TESTS

For chemical tests, made for each of the four levels surface, 4 m., 8 m., and 12 m., water was discharged from the brass water bottle into 250 cc. glass bottles which were tightly glass stoppered after being filled to overflowing. From each collection two such bottles were taken, the rest allowing for the liter centrifuge sample previously noted. A moist cloth over the bottles tended to keep down their temperature somewhat in transporting them back 9 miles to the laboratory, where tests were made. For the 32 month total period, 26 complete and two incomplete sets of samples for tests were available.

The outboard motor patrol boat used for most trips was so crowded that chemical tests on board were impossible. A much larger boat was available September and October, 1936, and from April to October, 1937, when it was removed from the lake. It could not be used in intervening months because the water level was too low in parts of the channels. But there was no thought of doing part of the chemical testing on board, until comparison of a year's oxygen records disclosed what seemed some rather unreasonably high quantities of dissolved oxygen. In September and October, 1937 trips, it was arranged to do the initial steps of the oxygen test on the big boat. These, after completion in laboratory, did show for reasons unknown somewhat lower oxygen content than the tests on water collected at same time, run entirely in the laboratory. The technique was precisely the same, and by the same person in this period of work; the method was the Rideal Stewart modification of the Winkler method. (Standard Methods of Water Analysis, 5th Ed., 1923.)

Because of a possible invalidity of the end results of some oxygen tests, it is not considered worth while to present a table of all results. Nevertheless, a summary is given, all figures being p.p.m. Surface water oxygen content varied from 6.13 (August, 1937) to 14.59 (January, 1938), but was usually between 10 and 14; of 28 surface monthly readings, the only ones below 10 were November, 1936, August, 1937, August, September and October, 1938, but also more oddly, March, 1939. For the most part oxygen content was high in spring. Several instances occurred of slightly higher oxygen content at 8 and 12 m. than at surface. Other surprises were some erratic ups and downs from month to month. But in many late summer and fall months, there was a marked decrease from top to bottom, especially in August and October, 1936, and June, August, September and October, 1938. The lowest content of all, at 12 m. was 2.20 in September, 1938. But usually the oxygen content at 4 m., 8 m., and 12 m., was not materially lower than surface content, in the fall overturn, November, during the winter, and during spring overturn, to beginning of summer.

The dissolved CO_2 was determined by the standard method of phenolphthalein indicator and n/44 sodium hydroxide. No CO_2 was

recorded for surface waters except under ice, January, 1938, when there were 0.4 p.p.m. and in February, 1938, 0.2 p.p.m. At 4 m. there were 7 instances of some CO_2, at 8 m. 19 instances and at 12 m. 19 instances, out of 26 cases of total vertical test results. There were actually 6 monthly readings, January, March, and April, 1937, March and April, 1938, March, 1939, when the CO_2 readings were zero from top to bottom.

The pH was determined by the La Motte colorimetric method. Throughout the work, pH varied from 7.6 to 8.8 in surface water, higher alkalinity occurring in late summer and early fall. There were several cases of identical pH through the entire vertical range, 8.0 in April, 1937, March, 1938, 7.8 in December, 1938, and 7.6 in February, 1938. More often there was a slightly lower reading (less alkalinity) in deeper water, but the largest vertical range at any one time was 1.6 (and only 9 cases of ranges of 1.0 or above). The lowest alkalinity was 7.1 at 12 m., October, 1936, and the total range was 1.7.

KINDS OF PLANKTON ORGANISMS

Plankton were identified to genera. Species determination for all was impossible. In many cases a genus was represented by only one species.

Since routine examination was in the Sedgwick-Rafter counting cell, requiring low power (16 mm. objective) many nanno-plankton, if small and scattered, may have been omitted. Six types of real nanno-plankton were studied. Three of these were smaller species of genera also included in net plankton.

Twenty-seven net plankton genera and separately six nanno-plankton were tabulated completely. For each month or collection, the separate number of organisms per liter from surface water, 4 m., 8 m., and 12 m. were recorded. In this paper these longer tables are omitted.

Most of the data on organisms per liter of the twenty-seven genera were those of the trap-net collections; some were from the water bottle centrifuged samples. The selection was made on the basis of studies reported on in the paper comparing critically the two collecting methods (Kraatz, 1940) and referred to in the introductory remarks on methods, above.

The blue-green alga Aphanizomenon counts were from centrifuged samples because in times of maxima far greater numbers were secured than from trap-net samples. The other Cyanophyceae were from trap-net counts, because centrifuging operations failed to retain the vast majority of the water bottle specimens.

On the other hand, diatom counts used were from water bottle samples for in these significantly larger numbers were found, especially in times of maxima, though not at all times. One exception was Stephanodiscus where net counts were used. This may seem arbitrary, but this genus was found in far more net samples than water bottle samples; numbers of water bottle samples had none while the comparable net sample had appreciable numbers. Possibly this is explained by the combination of relatively small water bottle sample, with not

TABLE II

PLANKTON. MIDDLE OF TURKEYFOOT LAKE

Organisms per Liter; each Figure an Average of the Four Depth Levels

Organisms	Aug. 17, 1936	Sept. 19, 1936	Oct. 17, 1936	Nov. 14, 1936	Jan. 9, 1937	Mar. 27, 1937	April 24, 1937	May 22, 1937	June 19, 1937	July 19, 1937	Aug. 20, 1937	Sept. 18, 1937	Oct. 16, 1937
Coelosphaerium	3,650	11,169	6,531	6,700	75	38		414	2,899	3,750	4,325	544	91
Microcystis	2,325	3,344	5,881	387			1,488	242	509	1,600	1,886	95	47
Anabaena	9,612	9,331	1,419	44					4,368	42,102	6,700	874	50
Aphanizomenon	6,562	77,188	50,025	16,069	3,075	2,263	500	1,313	221,500	70,175	800	750	
Melosira	1,000	312	2,344	6,625		175	600	250	500	2,625	288	750	660
Stephanodiscus				278	513	863	400			1,900		50	100
Synedra	1,500	312	1,875	4,625	5,475	2,550	24,000	3,363	50		275	150	500
Asterionella			312	1,750	4,988	220,250	940,250	28,625	350				
Fragilaria	2,750	3,125	312	1,231	38	1,313	4,500	2,625	1,000	2,313	1,438		50
Pediastrum	75		4	5	2	51		10	4	17	2	2	7
Ceratium	3,958	1,229	171	12		2	7	92	4,760	2,301	823	73	14
Codonella			6	15	196	1,380	147				2	3	6
Polyarthra	40	51	53	56	10	20	139	237	22	255	99	116	447
Keratella	222	192	157	186	241	172	312	1,073	141	377	407	334	323
Asplancha					1	1	7	8	11		7	16	25
Synchaeta						1					41	115	24
Notholca	3	8	3	5	4	5	3	22	14	28	2	14	3
Nauplius	78	53	18	91	83	129	269	76	39	90	22	62	11
Cyclops	25	46	15	31	58	57	74	74	6	11	12	10	9
Diaptomus	15	8			3	1		16	8	4		1	2
Daphnia	10	8		3	2		10	59	5	5		1	
Bosmina		1		1	1		5	5			1	3	17

TABLE III

PLANKTON. MIDDLE OF TURKEYFOOT LAKE

Organisms per Liter; each Figure an Average of the Four Depth Levels

Organisms	Jan. 15, 1938	Feb. 19, 1938	Mar. 19, 1938	April 16, 1938	May 21, 1938	June 18, 1938	July 16, 1938	Aug. 20, 1938	Sept. 17, 1938	Oct. 15, 1938	Dec. 3, 1938	Jan. 28, 1939	Mar. 25, 1939
Coelsosphaerium		2				488	1,550	2,775	950	252			
Microcystis							600	2,800	250	85			
Anabaena						7,750	16,050	5,600	1,900	400			50
Aphanizomenon						3,500	42,250	1,900	500	250	50	250	
Melosira		1,000	250	500			500	450	400	400	7,500	1,500	350
Stephanodiscus		55	135	450	465		4	50			3,558	1,763	4,250
Synedra	14,667	4,250	10,500	135,500	750			1,250	3,850	750	12,500	63,250	27,500
Asterionella			1,500	11,750	85,250	12,750					3,350	15,500	308,000
Fragilaria		1,000		750	2,750		2,250	500	1,600		300		450
Pediastrum		1		4	21		20	8	10	4	14		
Ceratium	4		3	2	258	16,300	139	92	31	3		1	1
Codonella	11	2	11	20	12	2					14	11	75
Polyarthra	7			717	195	183	161	87	68	94	36		24
Keratella	272	116	131	448	1,033	35	1,036	118	95	104	507	504	174
Asplanchna				1		13			5	7	7		
Synchaeta							45	4	13	1		4	
Notholca							8				8		
Nauplius	607	58	27	266	119	35	24	28	31	28	80	70	39
Cyclops	807	107	86	57	100	7	6	12	9	13	52	47	16
Diaptomus			3		10	20	10	1		1	2		
Daphnia	1		1	5	10	19	1		1				
Bosmina	16	11	3	1	73	1	2		5	2	8		

so abundant a population of this diatom. However, in three collections, December, 1938, January and March, 1939, Stephanodiscus occurred in much larger numbers in the water bottle sample. Net counts were used, as the other would show a very haphazard distribution.

TABLE IV

NANNO-PLANKTON. MIDDLE OF TURKEYFOOT LAKE

Organisms per Liter; each Figure an Average of the Four Depth Levels

Organisms	Aug. 17, 1936	Sept. 19, 1936	Oct. 17, 1936	Nov. 14, 1936	Jan. 9, 1937	Mar. 27, 1937	April 24, 1937
Coelsosphaerium naeg.	.....	19,813	.....	.....	.....	.....	.....
Oscillatoria (small sp.)	.....	.....	.....	.....	.....	.....	33,250
Synedra (small sp.)	.....	.....	.....	.....	.....	.....	170,000
Amphora	.....	.....	.....	.....	.....	.....	.....
Scenedesmus	500	625	1,258	1,500	.....	.....	8,750
Trachelomonas	1,750	8,000	3,438	2,063	.....	.....	.....

Organisms	May 22, 1937	June 19, 1937	July 19, 1937	Aug. 20, 1937	Sept. 18, 1937	Oct. 16, 1937	Jan 15, 1938
Coelosphaerium naeg.	.....	.....	.....	.....	.....	.....	.....
Oscillatoria (small sp.)	16,688	.....	.....	924,500	7,725,000	50,000	.....
Synedra (small sp.)	36,563	.....	36,000	2,538,500	450,000	95,000	.....
Amphora	.....	.....	.....	.....	.....	.....	.....
Scenedesmus	1,875	.....	913	2,275	.....	2,000	.....
Trachelomonas	.....	.....	.....	21,650	3,750	15,250	1,250

Organisms	Feb. 19, 1938	Mar. 19, 1938	April 16, 1938	May 21, 1938	June 18, 1938	July 16, 1938	Aug. 20, 1938
Coelosphaerium naeg.	.....	.....	.....	.....	.....	21,750	.....
Oscillatoria (small sp.)	.....	.....	.....	.....	.....	.....	.....
Synedra (small sp.)	68,000	.....	143,500	.....	.....	3,250	188,500
Amphora	.....	.....	.....	.....	.....	.....	.....
Scenedesmus	.....	.....	6,250	.....	.....	1,500	750
Trachelomonas	6,000	3,250	10,750	1,000	500	3,350	2,000

Organisms	Sept. 17, 1938	Oct. 15, 1938	Dec. 3, 1938	Jan. 28, 1939	Mar. 25, 1939		
Coelosphaerium naeg.	.....	.....	.....	.....	.....	.....	.....
Oscillatoria (small sp.)	667,500	21,250	122,500	390,000	.....	.....	.....
Synedra (smal sp.)	311,250	22,500	58,750	.....	.....	.....	.....
Amphora	18,982,500	225,000	.....	45,000	.....	.....	.....
Scenedesmus	1,500	.....	1,500	.....	.....	.....	.....
Trachelomonas	6,250	5,500	9,000	7,750	10,250	.....	.....

A few of the twenty-seven genera occurred in relatively fewer samples or in smaller numbers than others of their class. They were the blue-greens Aphanocapsa and Oscillatoria (a large species), the desmid Staurastrum, the Protozoa (or Algae) Mallomonas and Dinobryon.

The remaining 22 genera of net plankton appear in condensed tables. In these (Tables II, III) vertical distribution is lost, since each

figure of organisms per liter is the average of all 4 depth levels. Figures 4 to 8, made from these, show the seasonal distribution.

The six nannoplankton kinds were secured only from water bottle collections. Tables showing vertical distribution of the six genera of nannoplankton are also omitted for want of room, but a condensed table giving the average figures of organisms per liter for the vertical range of four levels appears (Table IV). One plankter, the small Coelosphaerium, was omitted; it occurred in only two collections of the twenty-six, though in large numbers. Figure 3 shows the seasonal distribution of the five nannoplankton.

Some other plankton types were occasionally found, but so sporadically that inclusion in tables and graphs would have given little information. Among those recognized were Navicula, Euglena, Phacus, Cosmarium, Closterium, Gonium, Pandorina, Glenodinium, the rotifer Chromogaster (Anapus) and Chydoris. A few scattered diatoms were not recognized. Several kinds of rotifers, maybe six, appeared as individuals, rather widely scattered, mostly in rather poor condition, and were not identified.

It should be added that Dr. Taft in minute examination of some samples, found, besides the abundant kinds, some Chroococcus, Gomphosphaeria, Coelastrum, Sphaerocystis, Crucigenia, Oocystis, Eudorina; many of these were rare, or if not for a certain sample, were in the collections as a whole.

Dr. Noland in minute examination of some samples noted besides certain abundant ones, the following zooplankton, Peridinium and uncommonly various Ciliates mostly in rather poor condition in the preserved material, including Vorticella, Campanella, Lembus, Halteria and possibly others.

VERTICAL DISTRIBUTION

The vertical distribution could be seen only in the extended tables comparing the organisms per liter in surface, 4 m., 8 m., and 12 m. water. A study of all this data showed that there was rarely a uniform distribution from top to bottom, that the differences were not of much significance, that they were not consistent, that is that sometimes numbers were larger for a higher level than a lower, and at other times were smaller for the same higher level than the lower. In the case of most blue-green algae there was a tendency, expecially in times of maxima to have more at surface and 4 m. than in deeper waters, though not quite so pronounced a difference as expected from laboratory conditions in which these blue greens would rise to the top in bottles and centrifuged water. Among the nannoplankton a few striking differences occurred. When the organisms were most abundant, the tiny Oscillatoria and the tiny Synedra, August and September, 1937, August and September, 1938, and the Amphora, September, 1938, were excessively abundant in the upper levels, and relatively few in the two deeper levels. The same was true of the small Coelosphaerium, not listed in the table. In these few cases, there was a close correlation with water temperature, the abundance going with high temperature. (See further discussion under seasonal distribution.)

SEASONAL DISTRIBUTION

The average number of organisms per liter for 22 plankton genera and separately for 5 other nannoplankton kinds were used for construction of the figures (3 to 8), as noted above. The graphs give a picture of the distribution, but it must be remembered that they are semi-logarithmic. A zero line had to be added (despite any mathematical objections), arbitrarily below the lower base line, which stands for either 1 or 10 in various graphs, and for 100 in Fig. 3.

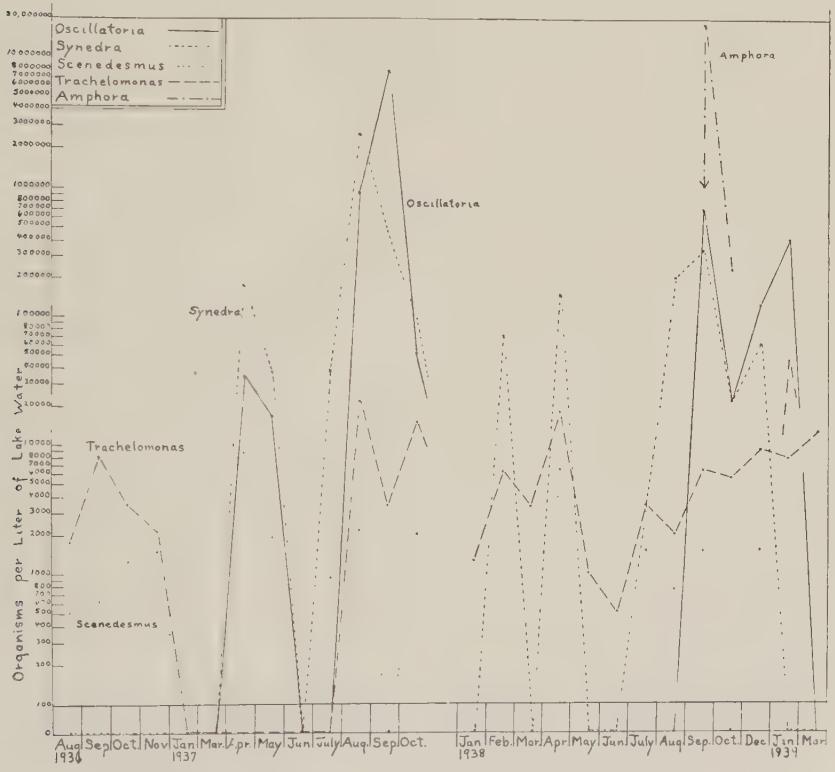


Fig. 3. Nannoplankton. Seasonal Distribution, from August, 1936, to March, 1939. Organisms per liter. Each reading is an average of four depth levels. Semi-logarithmic graph.

The various classes of plankton have long been recognized as having a somewhat typical cycle, with a period or two periods of maximum abundance annually, correlating approximately with the seasons. Information on this matter is summarized in texts of Whipple (1927) and Welch (1935). In the former, the seasonal climaxes are especially stressed (Chapter IX). Welch (pp. 236 239) also points out that despite seasonal periodicity there is much variation within a year and from year to year, and that instead of a taxonomic group being a unit, each

plankter in the last analysis is practically a unit in itself. In the graphs presented here, each plankton kind is shown in its own curve, but with those of its own taxonomic group, so that it can be seen how closely the members of a class coincide in their pulses. It was thought that additional graphs representing total plankton of each class could be dispensed with.

CYANOPHYCEAE

The annual period of maximum development of blue-green algae is late summer. In this study the individual kinds of Cyanophyceae were seen to have their maxima not coinciding precisely and not at exactly the same time nor as large each year.

Coelosphaerium of two different types was found. One type (Tables II, III) was large, often in large colonies, though of such range of size that it might have been a mixture of C. dubium and C. kuetzingianum. Colonies always had a bright color and contributed materially to the water bloom and rose uniformly to the top of laboratory vials and in centrifuging. The other (Table IV) identified as C. naegelianum, was found only in water bottle samples in two collections. Its cells were smaller, colonies smaller and definitely of a paler color. The large Coelosphaerium (Fig. 4) attained a maximum in September in two of the three years, but was also abundant in August and even in October. It developed and declined slowly so that its season in which it thrived lasted from late June practically to November.

Microcystis was somewhat less abundant than Coelosphaerium, had a shorter period of development, but nevertheless rather similar distribution. One minor peak of development, but almost equal to the late summer peak of the year, occurred in April, 1937. (Figure 4.)

Oscillatoria of large size occurred infrequently. But in the nannoplankton graph a tiny filament identified as Oscillatoria was very abundant. In 1937 a minor peak was evident in April, followed by a complete decline, a major peak in August and September, with rapid decline in October. But the next year's distribution differed somewhat; the major peak, September, was much smaller, a great decline followed, but there was a large peak in January. (Figure 3.)

Anabaena on the whole showed consistency. The filaments were always prominent, rather long, the count being of such so-called whole filaments. Small pieces were counted as fractions. It was an important contributing cause of water bloom. Anabaena reached its peak earlier than Coelosphaerium, and attained greater numbers. In the two years of complete summer records, the peak was in July, but almost as high in August. Autumnal decline was slower than early summer increase. (Figure 4.)

Aphanizomenon was somewhat similar to Anabaena, but reached far greater numbers and was sometimes important in the water bloom. In two years the great peak was in June and July; unfortunately no record was available for those months in 1936, which had a very large peak in September with only a small decline in October. (Figure 4.)

It is evident that not alone in late August and early September when more or less water bloom appears, is the class as a whole prom-

inent. Its season of thriving is much longer. There is a correlation with water temperature, of the class as a whole. But as noted above, Aphanizomenon which attained greatest numbers of all these listed among net-plankton, reached its greatest of all peaks one June, with somewhat less in July, and a big decline in August and more in September. The big June-July pulse was three times as high a peak as the next highest attained the preceding year in September. The third year the highest peak, one-fifth that of the highest of all, was centered in July. Water temperatures on the whole are 5° C. lower on the surface in June than in August. (See Table I, and Figure 2.) Other very

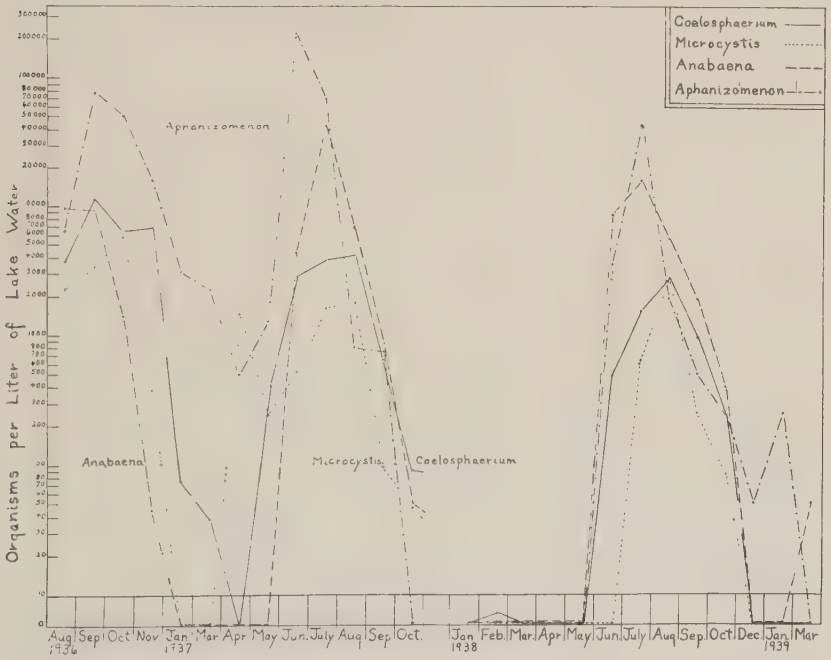


Fig. 4. Blue-green algae. Seasonal Distribution from August, 1936, to March, 1939. Organisms per liter. Each reading is an average of four depth levels. Semi-logarithmic graph.

abundant blue-greens, especially the small Oscillatoria of the nannoplankton, correlate their abundance more closely with the maximum temperatures.

Vertical distribution is not exhibited in the graphs. While much of the year the algae population differed only slightly at the several levels sampled, there was relatively far more increase at the surface, and nearly as much at 4 m., than in the deeper waters, at the late summer maxima or time of the water bloom. This, as was noted in temperature chart and graph, was the time of surface temperatures of 26° to nearly 28° C., and 25° to 26° C. at 4 m., but average temperatures of 19° C. at 8 m., and less at 12 m.

DIATOMACEAE

Diatoms are generally recognized as having a striking spring maximum and a secondary late fall peak, or the two pulses reaching about equal maxima. Whipple (p. 228) lists Asterionella, Tabellaria, Melosira, Synedra, Stephanodiscus, Cyclotella, and Diatoma, as being the chief genera exhibiting spring and fall maxima.

Melosira was not found distributed seasonally in quite this manner. There was no distinct spring peak, only a fair number throughout this as in most seasons. The only distinct peaks were in November, 1936,

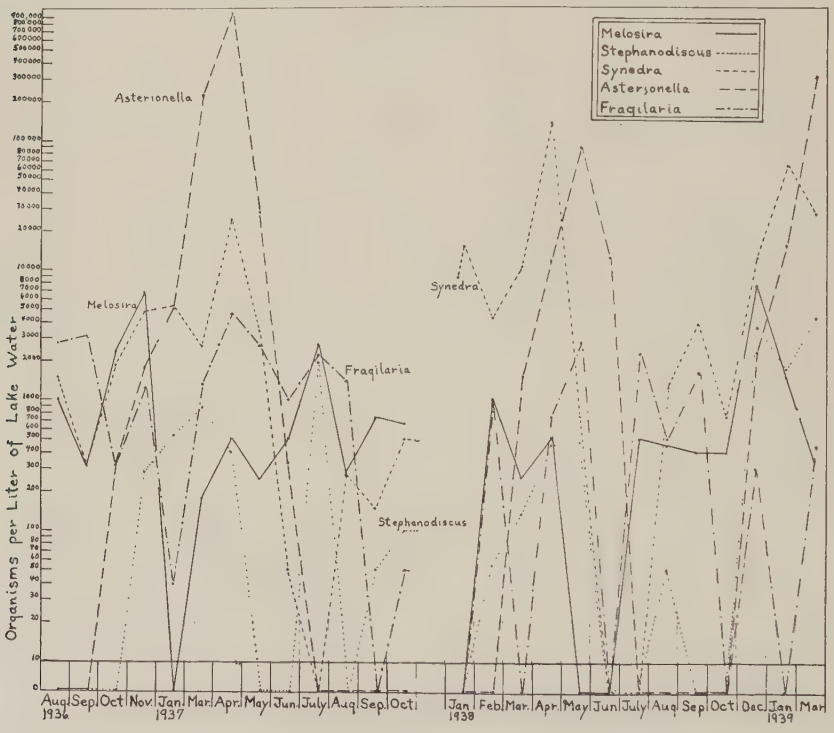


Fig. 5. Diatoms. Seasonal Distribution, from August, 1936, to March, 1939. Organisms per liter. Each reading is an average of four depth levels. Semi-logarthmic graph.

December, 1938, with the next largest pulses in July, 1937, and February, 1938. (Figure 5.)

Stephanodiscus was also found distributed in fair quantity in many months of the year, with a fairly broad spring peak, but also a July peak one year and a winter peak, December to January. In one year a long winter and spring pulse was continuous. (Figure 5.)

Synedra of a large species was prominent in net-plankton. (Figure 5.) A much smaller species, about one-fifth as long as the other, was found only in water bottle samples and shown in nannoplankton graph. The

large net-plankton species was more widely distributed during the year and common except in early summer. There was a high April period definitely each year, also large numbers in fall and one high peak January, 1939. The tiny Synedra occurred in tremendous numbers in a late summer 1937 peak, and large numbers in a spring pulse each year, with two separate peaks in spring 1938, and also an extended autumn pulse the same year. The greatest number of all attained (August, 1937), was actually eight times the number of organisms attained in the second highest peak. A re-check showed no late summer occurrence whatsoever in 1936. This tiny Synedra and one other diatom of the nannoplankton (Amphora) were the only ones which had, and then really only in the greatest maximum, a far greater number in upper than in deeper waters. (Figure 3.)

Asterionella showed the greatest spring pulses and attained the greatest total numbers of all diatoms except the tiny Amphora in its one great splurge. An outstanding peak was attained in April, 1937, though a decidedly smaller one next year and that delayed until May. The last collection made, March, 1939, showed an ascending population that probably reached a month later some figure like that of April, 1937. (Figure 5.)

Fragilaria occurred at least as uniformly throughout the year as Melosira and Stephanodiscus, though at the same time exhibiting small peaks in April and May and other minor peaks in erratic arrangement. (Figure 5.)

Amphora, a very small diatom (recorded in the nannoplankton group) was found present only in September and October, 1938, and January, 1939. Strangely, it was not even found in the similar periods in either of the other two years as another re-check showed. Of course, a plankter as small as this might have been overlooked if it occurred only as a few scattered in a counting cell, among debris and larger plankton, but any such numbers would have been irrelevant. Furthermore, the enormous maximum, 19 million, as in all other figures used in making graphs, is an average of four samples from surface to 12 m. Deeper waters had smaller numbers and surface water about twice the average number. (Figure 5.)

CHLOROPHYCEAE

Green algae were not represented by any types that were predominant in the lake plankton, though various kinds occurred in very small numbers in irregular distribution and three were found in larger numbers. Even one of these, the desmid Staurastrum, was omitted from the graphs. It occurred in just eight of the 26 monthly collections. Largest numbers were recorded in May, both in 1937 and 1938, but otherwise distribution was sporadic.

Pediastrum is recorded in Figure 6. It was found in rather small numbers but in quite a few months of the year. Only slight peaks or pulses were shown, in spring and in summer; one of August, 1936, was highest, March, 1937, was next largest and among the lesser peaks was one in December.

Scenedesmus, among nannoplankton, has peculiar distribution, with a number of peaks of which the most consistent was an April peak. There were also separate small peaks in November, 1936; August and October, 1937; and July, September and December, 1938.

PROTOZOA

Only certain flagellates were present and numbers of ciliates which were relatively rare. Dinobryon, Mallomonas, Trachelomonas, Ceratium and Codonella were followed through the collections. It is real-

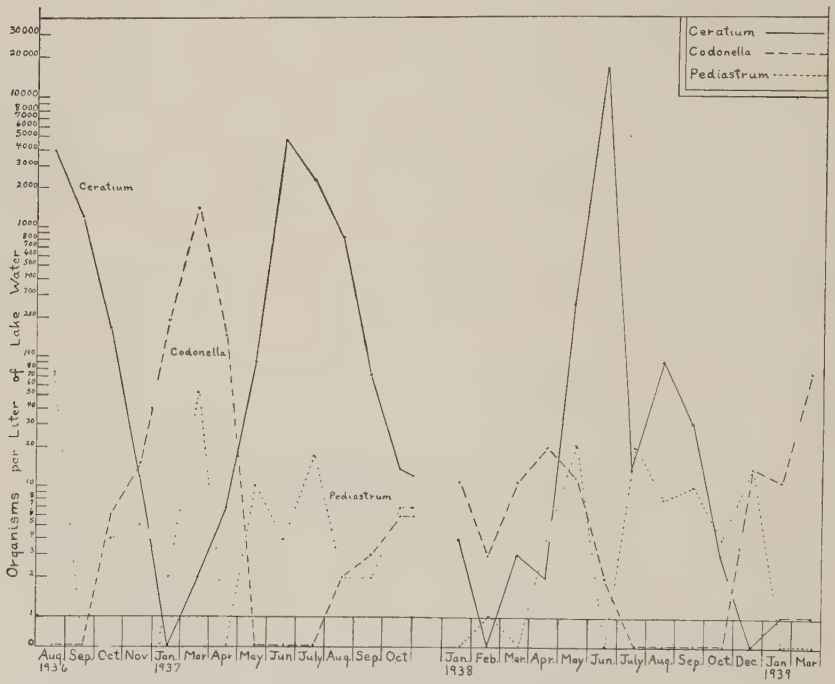

Ceratium
Codonella
Pediastrum
Organisms per Liter of Lake Water
Aug. Sep. Oct. Nov. Jan. Mar. Apr. May Jun. July Aug. Sep. Oct. Jan. Feb. Mar. Apr. May Jun. July Aug. Sep. Oct. Dec. Jan. Mar.
1936 1937 1938 1939

Fig. 6. Protozoa and a Green Alga. Seasonal Distribution, from August, 1936, to March, 1939. Organisms per liter. Each reading is an average of four depth levels. Semi-logarithmic graph.

ized that several of these types are classified as algae by various algologists, but for the present purposes they may well be grouped together here. Mallomonas and Dinobryon occurred less often and are omitted from the graphs. Their distribution seemed erratic. One decided peak for Dinobryon occurred in April.

Trachelomonas is on the nannoplankton graph (see Figure 3). The pulses were pronounced but not the same each year. An early autumn peak was most definite, but in one year a spring peak occurred, followed in fall by a gradually rising number that continued to increase somewhat through the winter and to next spring.

Ceratium (Figure 6) was a very prominent plankter, found nearly throughout the year. The great pulse occurred in a pronounced peak in June, though nearly as great a peak was reached in August when the first collections were made. The early summer pulse either continued somewhat, or repeated as another secondary pulse (August, 1938).

Codonella is a characteristic plankton ciliate having a lorica. It was present in many samples, but had a large peak in March of only one year, and minor peaks January, April, and December, and somewhat higher again in March following. (Figure 6.)

ROTIFERA

Rotifers formed a prominent group in the plankton. Rotifers are said to have their large numbers between June and November (Whipple, p. 235). Five genera were followed throughout. (Figure 7). Several

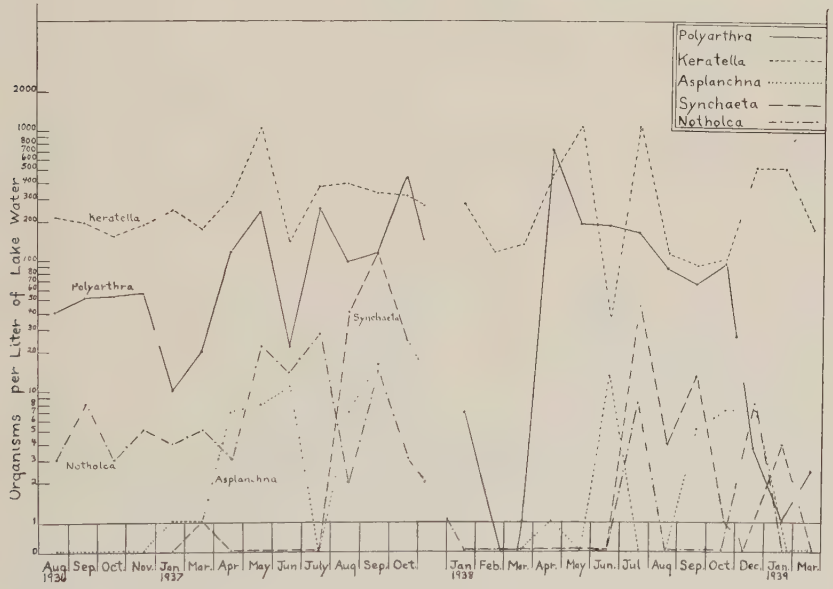


Fig. 7. Rotifers. Seasonal Distribution, from August, 1936, to March, 1939. Organisms per liter. Each reading is an average of four depth levels. Semi-logarithmic graph.

other kinds, not identified, were rare or scattered. Chromogaster was recognized, but also was apparently rare.

Polyarthra was found during nearly the entire year with only one considerable break in continuity in early spring one year. The highest peak occurred in one April, and this pulse decreased gradually during summer and late fall. In another year there were distinct though lesser peaks in May, July, and October.

Keratella (Anuraea) was the rotifer which was most uniformly distributed through the seasons. Increases that occurred resulted in a peak

in May, and in May and July the next year, but with a quick decrease in June both years. The winter season did not show any minimum, in fact, in one winter the number ran far higher than the annual average.

Asplanchna had a far more restricted distribution, but variable. One year there was a small peak April to June and another August to October; another year a peak in June and one from October to December, whereas in another year none were found in samples of late summer and fall.

Synchaeta was likewise restricted, and numbers were small. A decided pulse occurred one September. In another year there were three, decreasing sized pulses, June, September, and January.

Notholca showed a little more continuous distribution for approximately a year with a general increase in late spring and summer but in another year it appeared less often with a slight peak in July and another in December.

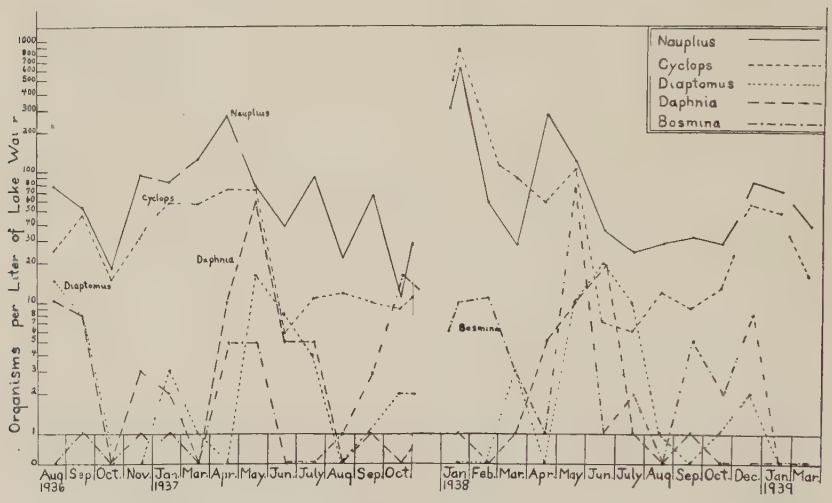


Fig. 8. Entomostraca. Seasonal Distribution, from August, 1936, to March, 1939. Organisms per liter. Each reading is an average of four depth levels. semi-logarithmic graph.

ENTOMOSTRACA

The smaller Crustacea are the largest of the normal plankton organisms, and though their numbers do not seem large, they make a prominent part of plankton life. Cyclops and their larvae, Nauplius, were really rather abundant, other types more occasional, and on the whole not very common. It is perhaps surprising that more Cladocera should not have appeared. (See Figure 8.)

Nauplius larva was found commonly during most of the year. It exhibited a number of slight pulses and declines. The most consistent peak was in April, but one January peak was far higher. Minima were in October. The Nauplius was that of Cyclops in most cases probably,

though in this type of routine work it is not at all sure that Diaptomus larva was separable from Cyclops.

Cyclops had a distribution somewhat similar to Nauplius. An unusually high peak of development occurred January, 1938. Otherwise there was little consistent seasonal variation. Points of minima were in October, June and July. On the whole, the numbers were up well from the middle of the winter, through spring until May.

Diaptomus appeared in small numbers, but with decided pulses, going to vanishing points in samples after each pulse. Separate peaks were in succession in August, January, May, October, and the next March, June and December. There is at least a slight regularity in the intervals between these pulses, but they do not come at the same time from year to year.

Daphnia had, possibly accidentally, a distribution very similar to that of the Copepod Diaptomus; the pulses were, with some exceptions, practically at the same time. The highest peak was in May, 1937; one a year later in June was, however, only a third as high. Otherwise, no pulses were ascertainable. A fairly consistent low point occurred in October.

Bosmina appeared in smaller numbers than the other Entomostraca, on the whole. But there were also a few real pulses, the largest in October, 1937, a smaller one in the following February and a very large one in May.

SUMMARY

Plankton organisms were collected in one central pelagic station in Turkeyfoot Lake, from August, 1936, to March, 1939. In the 32 month period, 26 monthly collections were made. Months missed were chiefly in winter, but only once were two consecutive collections missed.

Temperature records were made and a table and graph of much of this data is presented.

Tests of dissolved O_2, CO_2, and pH colorimetric tests were made and a brief summary of this data is presented.

Plankton was collected by trap-net and water bottle and counts made under low power of all organisms as far as size permitted, from both collecting devices. A few kinds of real nannoplankton were secured only from the water bottle. Of those collected by both devices, the net counts were found most satisfactory for most of the plankton, but the water bottle counts best for most diatoms and one of the blue-greens.

Of many plankton kinds, 27 genera regarded as net-plankton and six nannoplankton were tabulated. Of the former, 22, and of the latter, 5 are presented in condensed tables and graphs.

Vertical distribution was studied, samples having been from four levels in all collections. No definite or consistent trends

in the vertical range could be ascertained, for any groups except in the case of some blue-greens and also of two of the smallest diatoms, and then only in times of great maxima, which were in a late summer water bloom when surface water temperatures were highest.

Seasonal distribution was the main objective. A set of six graphs, each graph comprising the group of related types, shows the seasonal cycle with pulses for all the main plankton genera. The classes had, as far as classes do have any uniform maximum pulses in definite seasons, the expected seasonal arrangement, including most prominently the one great late summer development of the blue-greens and the prominent spring pulse of diatoms. But in most groups there were many pulses, different for different genera, irregular through the seasons and differing somewhat in successive years.

LITERATURE CITED

Kraatz, W. C. 1931. A Quantitative Net-Plankton Survey of East and West Reservoirs, near Akron, Ohio. Ohio Jour. Sci., Vol. XXXI, No. 6, pp. 475–500.

1940. A Comparison of Plankton Counts from the Trap-Net and Water Bottle Centrifuge Techniques. Ohio Jour. Sci., Vol. XL, No. 3, pp. 151–161.

Ricker, Wm. E. 1938. On Adequate Sampling of the Pelagic Net Plankton of a Lake. J. Fish Res. Bd. Can. 4 (1), pp. 19–32.

Standard Methods of Water Analysis. 1923. 5th Ed. American Public Health Association.

Welch, Paul S. 1935. Limnology. McGraw-Hill Book Co., pp. 1–471.

Whipple, G. C. 1927. The Microscopy of Drinking Water. 4th Ed. John Wiley and Sons, pp. 1–586.

Adsorption

In a small book, "Some Problems in Adsorption," published by the Cambridge University Press, J. K. Robertson has presented a rather complete review of this very interesting field to which he himself has made a very definite contribution. The work is divided into seven chapters, preceded by an author's preface. In the preface the author presents a brief account of events that led up to the experimental investigations, the discussion of which is contained in the seven chapters of the book. In chapter I the experimental methods are presented, and succeeding chapters are devoted to heat of adsorption; formation of adsorbed films; evaporation processes and the formation of atomic hydrogen; effects of dipole interaction and properties of oxygen films on tungsten.

The discussion is presented in a very readable style which can be grasped by anyone with an intermediate training in physics. It can be recommended very sincerely to students of physics who are interested in obtaining an *introductory* knowledge of the problems of adsorption.—*H. H. Nielsen.*

Some Problems of Adsorption, by J. K. Robertson. 119 pp. Cambridge, at the University Press; in New York, the Macmillan Co., 1940. $2.00.

SEBEKIA OXYCEPHALA (PENTASTOMIDA) FROM FLORIDA FISHES AND SOME NOTES ON THE MORPHOLOGY OF THE LARVAE

CARL ERNEST VENARD

and

RALPH V. BANGHAM

Sebekia oxycephala (Diesing) Sambon, 1922, lives in the lungs, trachea, and pharynx of crocodiles and alligators which inhabit South America and the southern portion of North America. Developmental stages have been reported (Heymons, 1935) from fishes, snakes, a lizard, and crocodiles. The genus Sebekia contains six additional species, all of which are parasitic in alligators and crocodiles. *S. oxycephala* is not very well known and there is less information on the other species.

In 1928 Holl created a new genus and a new species for linguatulids from *Eupomotis gibbosus* (L.) and *Ameiurus natalis* (Le Sueur) taken from an artificial lake near Gibsonville, North Carolina. He called his specimens *Bdukus ichthyius*. Heymons believes that Holl's species is the larval form of *Sebekia oxycephala*.

Bangham (1939) studied the parasites of fish, particularly the sunfish family Centrarchidae, collected near Englewood, Florida. Larval linguatulids, which resembled *Bdukus ichthyius*, were found. They were different, however, in the distribution of the stigmata and Doctor Holl very kindly loaned us two specimens of *B. ichthyius* for comparative studies.

The internal anatomy of *Sebekia oxycephala* is very imperfectly known. Heymon's illustration of a larva deals with external features; his illustration of the anterior portion of an adult male supplies information on the sexual organs. The material collected by Bangham furnishes additions to our knowledge of the anatomy, geographical distribution, and hosts of *Sebekia oxycephala*.

ANATOMICAL STUDY

Thirty-one parasites were collected and preserved in five per cent formalin. Some were killed in their cysts and others were dissected out of them. The specimens were stained in Delafield's haematoxylin and mounted in balsam on slides. The stain entered through the mouth and anus to some extent, but a few specimens had been injured and the

chitinous covering was not intact. The internal organs in such individuals were favorably colored for observation.

Within its cyst the larva assumes a characteristic attitude. The entire body is ventrally flexed and the abdominal portion is coiled underneath the head (Fig. 3). Young individuals show no evidence of segmentation and the head is large in proportion to the remainder of the body. The hooks and internal organs are incompletely developed. The cysts are 2.6 mm. in diameter and white in color. They were found at the surface of the liver under the peritoneum and in the mesenteries.

Completely developed encysted individuals, when removed from their coverings, are 3 mm. to 5.5 mm. in length and 0.4 mm. to 0.79 mm. in greatest width. In general, males are smaller than females. The total number of segments is from 64 to 68. The musculature of the body wall and hooks is functional and the shape of the body and position of the hooks show some variation in the different specimens. The widest part of the body is at the middle and it gradually diminishes in diameter toward the posterior end which is blunt. The terminal segment is of the same length as an individual segment anterior to it, and bears the anus at its tip. Towards the head the diameter becomes less but there is no definite neck. The first annulus is a very short distance posterior to the mouth.

The head bears the four hooks and mouth as conspicuous structures (Figs. 1 and 4). The hooks may be extended or retracted. They are similar in size and shape (Fig. 8).

The stigmata are found on all segments and the head. They are particularly evident in cuticula which has become loosened from the underlying tissues. The stigmata do not occur in definite rows as described and illustrated by Holl (1928) and Heymons (1935) for the specimens they studied. Their arrangement is irregular (Fig. 7) and there is no definite pattern. This irregularity is greater in younger than in older specimens and is easier to see in relaxed than in contracted individuals.

The intestine and lateral glands are similar in both sexes. The stomadaeum is quite short, extending below the mouth a distance equivalent to one segment. The proctodaeum is much longer and is found

---

EXPLANATION OF PLATE

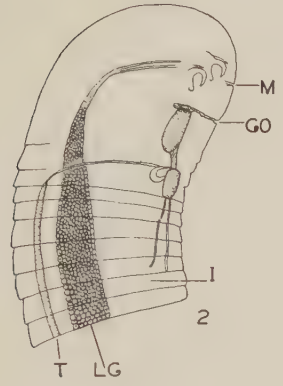
Fig. 1. Head end of a well cleared male, ventral view.
Fig. 2. Anterior end of male, lateral view.
Fig. 3. Encysted male.
Fig. 4. Head end of female, ventral view. The hooks are well extended and no internal morphology is visible. Figures 1, 4 and 5 are drawn at the same magnification.
Fig. 5. Posterior end of a female, lateral view.
Fig. 6. Segment from Holl's specimen number 940, showing distribution of the stigmata.
Fig. 7. Segment from a Florida specimen.
Fig. 8. Lateral view of a hook.

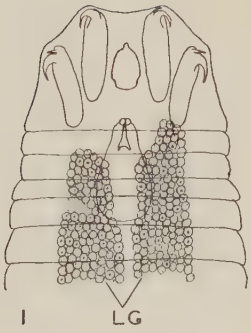
ABBREVIATIONS:

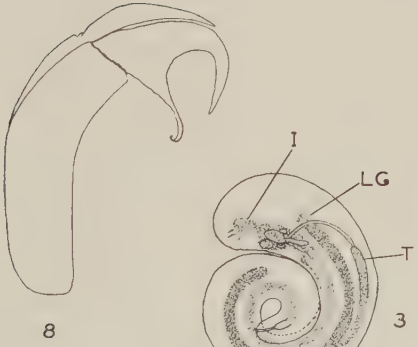
GO—Genital opening.
I—Intestine.
LG—Lateral gland.
M—Mouth.
T—Testis.
U—Uterus.

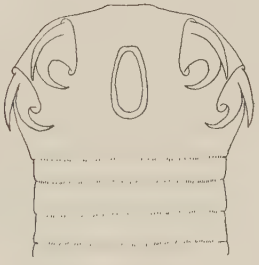
Sebekia oxycephala
Venard and Bangham

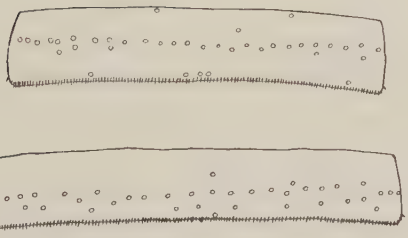
PLATE I

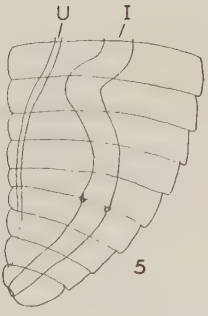












in the last four segments. The mid-intestine is of fairly uniform diameter although largest a short distance below the mouth. It pursues a rather winding path through the body. The pair of lateral glands extends, one on each side of the body, from the first segment to the fiftieth or fifty-fifth. The glands are voluminous and their cells are large. Two ducts emerge from the glands at their anterior ends and bend towards the bases of the hooks.

The sexual organs of the male (Fig. 2) are distinct but the individual structures are not named since the connections between them cannot be determined with certainty. The organs, in an earlier stage of development where they appear quite different in shape and arrangement, are evident in a young encysted specimen (Fig. 3).

The sexual organs of the female cannot be seen except for a dorsally placed ovary and a ventral vagina. The sexual opening appears to be on the last segment and anterior to the anus (Fig. 5).

HOSTS

Eighteen fish were infected with one to six linguatulids which were usually encysted in the mesenteries. The species of fish and the numbers of each that were infected are:

1 Bowfin, *Amia calva* Linn.;
1 Mosquito-fish, *Gambusia affinis holbrookii* (Girard);
2 Black-spotted sunfish, *Sclerotis punctatus punctatus* (Valenciennes);
1 Florida long-eared sunfish, *Xenotis megalotis marginatus* (Holbrook);
6 Stump-knocker, *Eupomotis microlophus* (Günther);
5 Warmouth bass, *Chaenobryttus gulosus* (Cuvier and Valenciennes);
2 Black crappie, *Pomoxis sparoides* (Lacépède).

The total numbers of these fish examined are, in the order given above, 21, 143, 18, 14, 49, 90, and 79. The infected fish were obtained from small pools and ponds near the channels of large streams. Fish were also taken from the Myakka and Peace Rivers, Lake Okeechobee and Everglades Canals but none of them carried this parasite.

Species of fish in which linguatulids were not found and the numbers of each examined are:

Lepisosteus platyrhincus De Kay, 82;
Dorosoma cepedianum (LeSueur), 7;
Erimyzon sucetta sucetta (Lacépède), 70;
Opsopoeodus emiliae Hay, 25;
Notemigonus crysoleucas bosci Valenciennes, 43;
Ictalurus lacustrus punctatus (Raf.), 13;
Ictalurus catus (Linn.), 8;
Ameiurus natalis (LeSueur), 45;
Ameiurus nebulosus marmoratus (Holbrook), 22;
Schilbeodes gyrinus (Mitchill), 1;
Esox niger LeSueur, 10;

Fundulus grandis Baird and Girard, 8;
Fundulus majalis (Walbaum), 10;
Fundulus similis (Baird and Girard), 24;
Fundulus notatus (Raf.), 2;
Fundulus chrysotus (Günther), 84;
Fundulus cingulatus (Cuvier and Valenciennes), 16;
Fundulus seminolis Girard, 14;
Floridichthys carpio carpio (Günther), 3;
Jordanella floridae Goode and Bean, 70;
Cyprinodon variegatus variegatus Lacépède, 6;
Heterandria formosa Agassiz, 21;
Mollienesia latipinna LeSueur, 93;
Trinectes maculatus (Raf.), 4;
Menidia beryllina atrimentis Kendall, 10;
Labidesthes sicculus vanhyningi Bean and Reid, 17;
Mugil cephalus Linn., 6;
Huro salmoides (Lacépède); 86;
Helioperca macrochira (Raf.), 104;
Enneacanthus gloriosus (Holbrook), 12;
Elassoma evergladei Jordan, 1;
Centropomus undecimalis (Bloch), 4;
Eucinostomus gula (Cuvier and Valenciennes), 13;
Dormitator maculatus (Bloch), 14;

These fish were identified with the aid of the key to the fresh-water fishes of Florida by Carr (1936).

Due to the fact that *Sebekia oxycephala* has been found in many hosts, the absence of this parasite from the species of fish listed above would probably indicate lack of opportunity of becoming infected rather than resistance to infection.

DISCUSSION

A comparison of the specimens from Florida with specimens of *Bdukus ichthyius* leaves no doubt that they are identical. They agree in all details, but since the distribution of the stigmata is not the same as the published account for *B. ichthyius*, comment on this discrepancy is necessary. The stigmata of *B. ichthyius*, in general, form a circle around each segment as Holl has described. However, they also occur over the entire surface of most segments. This fact is indicated in Figure 6 which is drawn from one of Dr. Holl's specimens. Segments which are contracted show a fairly even row of openings. This is due to the fact that those openings near the middle of the segment remain open whereas the others are either closed or otherwise obscured from view.

Heymon's illustration of the larva of *Sebekia oxycephala* creates the impression that the stigmata on each segment occur in a single row, but close inspection reveals that these rows are very irregular and approach the condition described above.

There is no doubt that the larva which Heymons calls *S. oxycephala* is identical with *Bdukus ichthyius*. If these linguatulids actually are larvae of *S. oxycephala*, then *B. ichthyius* becomes a synonym since the adult was named first. The identity of these larvae as *Sebekia oxycephala* is suggested by the structural similarity between the larvae and the adults and a correspondence in their geographic distribution. The specimens from Florida fishes yield considerable information to support this contention.

SUMMARY

Linguatulid larvae, identical with *Bdukus ichthyius* Holl, 1928, and secured from Florida fishes, have been studied. Heymon's opinion that *B. ichthyius* is the larval form of *Sebekia oxycephala* (Diesing) Sambon, 1922, is supported. Comments are made on the morphology and ecology of this species, including the reporting of seven new fish hosts.

REFERENCES

Bangham, R. V. 1939. Parasites of Centrarchidae from Southern Florida. Trans. Am. Fish. Soc., 68: 263–268.

Carr, A. F,, Jr, 1936. A key to the fresh-water fishes of Florida. Proc. Fla. Acad. of Sci., 1: 72–86.

Heymons, R. 1935. Pentastomida. Bronn's Klassen und Ordnungen des Tierreichs. 5 Band, 4 Abteilung, 1 Buch.

Holl, F. J. 1928. A linguatulid parasite from North American fishes. Journ. Parasitol., 15: 63–66.

More Haldane

The prolific Mr. Haldane has collected into one volume some seventy short articles which had previously appeared in *The Daily Worker*. They cover a wide range of scientific subjects, from food to stars. Some are very well written and of extreme interest; others apparently were written just in time to catch the Thursday dead-line. Mr. Haldane's opinion of Mr. Haldane has not suffered as the years have passed.—*L. H. S.*

Science and Everyday Life, by J. B. S. Haldane. 284 pp. New York, the Macmillan Co. 1940. $2.00.

THE ALIMENTARY TRACT OF VESPULA MACULIFRONS BUY.

(HYMENOPTERA: VESPIDAE)

ROBERT THOMAS MITCHELL
Department of Zoology and Entomology,
Ohio State University,
Columbus, Ohio

Colonies of the common yellow jacket, *Vespula maculifrons* Buy., are subterranean. The nest is usually in a bank of earth that is elevated from surrounding ground, from which location the drainage of water is good. The normal food for the species consists of juices and pulp of well-ripened fruit, meats, and soft-bodied insects. Unlike the honey-bee, the yellow jacket neither collects nor eats pollen.

Observations made at the very outset of the work upon the gross anatomy of the digestive tract revealed its similarity to that of the honey-bee. The author intends therefore in several instances to compare the alimentary canal of this wasp with the canal of the honeybee. As the basis for comparison the author will use the work of Snodgrass as presented in his "Anatomy and Physiology of the Honeybee" (8).

The material used for the study consisted of seventy-five workers from a single colony in Columbus, Ohio. These were collected in October after a killing frost and about two weeks previous to the hibernation period for the queen and the termination of the colony.

The author wishes to express his sincere appreciation for the helpful suggestions and criticism of Doctor C. H. Kennedy under whose direction this work was undertaken.

TECHNIQUE

Immediately after being killed, the body wall of some of the specimens was cut along the dorsal median line and of others along the ventral median line. The insects were then placed in Kahle's solution for twenty-four hours for fixation of the tissue, after which time they were stored in 70 per cent alcohol. Parts of the tract for sectioning were dissected, stained in borax carmine, cleared in cedar oil and then imbedded in paraffin blocks. Sections three to five microns thick were cut from the block and were then stained with Haemalum (Mayer's newer formula) for nuclei and Fast Green FCF stain for the cytoplasm and cell walls.

THE GROSS ANATOMY OF THE DIGESTIVE TRACT

The alimentary canal is approximately one and one-half times the length of the insect body (Pl. I, Fig. 1). The stomodeum or fore-intestine, which is of ectodermal origin, consists of four structures: namely, the pharynx, oesophagus, crop, and proventriculus.

The Pharynx. The pharynx, situated just posterior to the mouth, is triangular in shape. Around its anterior border is a heavily sclerotized strip. The upper surface of the pharynx possesses a rectangular lamella which is rounded at the end and bears many simple hairs. The pharynx extends dorsally to a point above the level of the attachments of the antennae where it narrows to the diameter of the oesophagus.

The Oesophagus. The osesophagus is a straight narrow tube extending posteriorly from the end of the pharynx through the foramen magnum into the thorax. Through the prothorax and mesothorax the oesophagus is completely surrounded by the thoracic salivary glands. From the mesothorax it progresses in a straight line through the metathorax and the petiole of the insect body, at which point it enters the abdomen. Here the tube widens considerably, forming the crop, which among the bees is termed the honey stomach. (Pl. I, Fig. 1, and Pl. II, Fig. 1.)

The Crop. The size and position of many of the organs in the abdomen vary according to the process of digestion in progress at the time the insect is killed. The crop (Pl. I, Fig. 1) occupies the median part of the first abdominal segment and the anterior portion of the second segment. The crop is capable of great distension; and when it is expanded, the walls of the crop are thin enough to render the food within visible. When the crop is thus enlarged, one can see the proventriculus or gizzard protruding anteriorally into the lumen of the crop. (Pl. II, Fig. 1.)

The Proventriculus. The opening into the proventriculus is X-shaped, indicating the presence of four muscular lips between which the food must pass. The posterior third of the gizzard narrows rapidly to form a short narrow cylindrical peduncle. A tube, the oesophageal valve, projects caudad from the proventriculus through the middle of the ventriculus for approximately one-third the length of the stomach. (Pl. II, Figs. 1 and 2.)

The Ventriculus. The ventriculus or stomach (Pl. I, Fig. 1) is the most conspicuous organ of the entire digestive tract. It varies in respect to position, but in general, it extends from the second abdominal segment to the fifth and along its course forms two loops, one in the second abdominal segment and the other in the third. The ventriculus is annulated, light rings being present where the epithelium within is folded and dark where the epithelium is but a single layer thick and the stomach contents can be seen through it.

A sharp bend occurs at the posterior end of the stomach where the Malpighian tubules enter the pyloric valve.

The Malpighian Tubules. The entrance of the Malpighian tubules into the tract marks the end of the mesenteron or mid-gut and the

beginning of the proctodeum or hind-gut. The Malpighian tubules (Pl. I, Figs. 1, 2, 5, 6, and Pl. II, Fig. 1) numbering one hundred or more, are greatly intertwined and wound about the base of the ventriculus and about the intestine. The tubules are very long, being for the most part two-thirds as long as the ventriculus. Each one is attached singly on the circumference of the valve. The distal ends of the tubules lie free in the body cavity.

The Small Intestine. At the end of the pyloric region the tract becomes reduced to about a third of the diameter of the valve. The small intestine (Pl. II, Fig. 1) is marked longitudinally by six light and dark stripes, the light stripes corresponding to the six folds of the epithelium within. The small intestine never follows a straight course but is invariably curved and looped in various ways.

The hind end of the small intestine is indicated by the termination of the previously mentioned stripes, and here the tract becomes greatly enlarged, forming the rectum.

The Rectum. The rectum (Pl. I, Fig. 1, and Pl. II, Fig. 1) like the crop is capable of considerable distention. When not distended the rectum is somewhat depressed; but when it is expanded, it is almost round. The presence of six rectal pads within the rectum is indicated by six white areas shaped like double convex lenses situated longitudinally and extending nearly one-half the length of the rectum. From its middle the rectum tapers to a slender tube which opens at the anus.

There is no decided difference between the external appearance of the alimentary tract of *Vespula maculifrons* and that of the honeybee. A minor difference that was noted is in regards to the rectal pads, which in the honeybee from external appearance are much more narrow and shorter than those in the yellow jacket.

THE HISTOLOGY OF THE ALIMENTARY TRACT

The Oesophagus. The walls of the oseophagus are very muscular, there being a thick layer of both longitudinal and circular muscles. The latter encloses the former. The epithelium is evidenced only by the presence of nuclei scattered within the thick convoluted intima.

The Crop. The structure of the crop (Pl. I, Fig. 3) is fundamentally the same as that of the oesophagus, but the convoluted chitinous intima is much thicker, almost obliterating the lumen. The similarity of structure between these two organs is expected, since they are both of ectodermal origin, being formed by an invagination of the ectoderm of the anterior portion of the embryo, and since the crop is merely an enlargement of the posterior portion of the oesophagus.

The Proventriculus. The proventriculus is of ectodermal origin likewise but differs markedly from the structure of the two previous organs of the stomodeum. The anterior opening of the proventriculus is X-shaped, made so by the presence of four thick columns of longitudinal muscle. (Pl. I, Fig. 4.) The longitudinal muscles of the crop diverge upon reaching the proventriculus and assume two different positions. (Pl. II, Fig. 2.) Some strands turn inward and connect with the thick columnar layers, accompanied in like manner by the circular

muscles which form in thick layers around the columns of longitudinal muscles. Other strands of longitudinal muscle continue along the exterior of the proventriculus, making three muscle layers in the proventriculus, a thin layer of longitudinal muscle along the exterior and a thick layer of circular muscles which encircle the third set or inner thick longitudinal muscles. It is from the base of the crop therefore that the order of muscle layers is reversed. This new order, with longitudinal muscles exterior to circular muscles, extends from this point to the end of the alimentary canal.

In the honeybee Snodgrass states that the circular muscles cease at the rear end of the crop and that a new layer of circular muscles arises in the muscular columns of the proventriculus. In *Vespula* these circular muscles are a continuation of the circular muscles of the crop.

Entad to the longitudinal muscle column is a single layer of epithelium evidenced only by nuclei that lie in a straight line, the cell walls not being clearly defined. A thick, dense, and not so convoluted layer of intima lines the lumen of the gizzard. Chitinous projections or spines exist along the intima part of the way through the proventriculus.

The thick layers of longitudinal muscles taper toward the posterior end of the gizzard and finally disappear entirely at the oesophageal valve. The thick layers of circular muscles also taper toward the oesophageal valve but instead of vanishing continue to comprise a part of the musculature of the ventriculus.

The Oesophageal Valve. The oseophageal valve (Pl. II, Fig. 2, OES. V), a prolongation of the epithelium and intima of the proventriculus, projects one-third of the way through the stomach. At the distal end of the prolongation the epithelium of the valve becomes joined to an outgrowth of the epithelium of the ventriculus. This strip of ventricular epithelium one layer thick progresses anteriorally adjacent to the epithelium of the valve until it arrives at a point opposite to the first annular ring, where it turns outward and the cells become attached to the main portion of the epithelium of the stomach.

The Ventriculus. The epithelium of the ventriculus lies in regular sinuous folds, each annular ring visible from the exterior corresponding to a fold in the epithelium. (Pl. III, Fig. 1.) The epithelium is not so irregular as in the honeybee. The epithelium rests on a thin basement membrane. The cells are columnar in shape and rounded at the apex. Those at the tips of the folds projecting into the lumen tend to be larger than the rest of the cells. The nuclei are very conspicuous and lie either in the middle of the cell or toward the base, rarely toward the tip of the cell. Circular muscles encircle the stomach close to the basement membrane and can be found lying between the folds of the epithelium. A layer of longitudinal muscle borders the stomach, and in some instances a thin peritoneum joins these muscles.

Surrounding the food particles in the lumen of the stomach may be seen one to several peritrophic membranes. These membranes are formed from a gelatinous-like secretion of the ventricular epithelium. (Pl. II, Fig. 3.) The free ends of the epithelium projecting into the lumen become filled with the material and become greatly enlarged and club-shaped. The cell wall then bursts, and the secretion is emitted.

The substance thus secreted coagulates on its ental surface next to the food to form the thin film or peritrophic membrane. In the posterior region of the ventriculus there may be six or more peritrophic membranes present at one time. In the anterior portion they are fewer in number. At any time a peritrophic membrane is being laid down in some section of the ventriculus. Some cells are in active secretion while others remain in a different stage of the process. (Pl. III, Fig. 1.) After being formed, the membranes evidently pass along the tract with the food and pass out the anus as a sheath around the feces, which is characteristic of this type of peritrophic membrane that Wigglesworth terms "Type i." (12).

The presence of chitin, detected in the peritrophic membrane of the honeybee by Campbell (3), is the basis for the assumption that the peritrophic membrane must arise from the oesophageal valve, since only epithelium of ectodermal origin has been credited with the ability to secrete chitinous substances. In some insects such as *Sciara* (2), other Diptera, and earwigs (12) the peritrophic membrane is of ectodermal origin, but for the peritrophic membrane in the honeybee and the wasp evidence is sufficient to conclude that the peritrophic membrane arises from the ventricular epithelium, which is generally said to be of mesodermal origin. We must assume then, since chitin has been detected in the peritrophic membrane of the honeybee, that the epithelium of the ventriculus is capable of secreting chitinous material.

The epithelium of the ventriculus secretes not only the substance for forming the peritrophic membrane but also some nucleated bodies which probably contain digestive enzymes. (Pl. II, Fig. 3.)

Regenerative epithelial cells are rare in *V. maculifrons*. A few were found occurring singly or in pairs at the base of a fold in the epithelium. Near the posterior end of the stomach, where the epithelium is less folded and where the cells are longer, a few nidi were found where three or four regenerative cells might occur. (Pl. III, Fig. 3, RC.)

The posterior extremity of the stomach is marked by the entrance of the Malpighian tubules into the tract and by termination of the gelatinous secretion at the inner edges of the cells.

The Malpighian Tubules. The Malpighian tubules are composed of large cells with large and distinct nuclei. The inner surface of the epithelium is smooth, and the cells bulge out into the lumen. These cells rest on a conspicuous basement membrane. (Pl. I, Figs. 2 and 6.)

The Pyloric Valve. Beyond the point of the entrance of the tubules the epithelium is composed of large cuboidal cells with large nuclei. There are both longitudinal and circular muscles present, the former existing as only one layer but the latter increasing in abundance and becoming heavily massed to form a sphincter of the valve. The extremities of the pyloric region are marked by the existence of short and sharp spine-like projections upon the intima on the inner surface of the epithelium. These projections are especially abundant in areas where there appears to be an extra thick layer of intima. In Plate III, Fig. 3, S, the spines have been enlarged beyond their relative size to make them visible upon reproduction.

It is doubtful whether these spines have any definite function. It has been suggested to the author that they may be traces or remnants of the process of the tearing apart of the tissues in this area as the insect passed from the larval stage with a closed hind-gut into the adult stage in which the hind-gut is functional.

The Small Intestine. The epithelium of the small intestine (Pl. III, Figs. 3, 4 and 5) is thrown into six longitudinal folds, occurring as a single layer of cells. It possesses a layer of intima on its free surface. The nuclei are large and round and located near the bases of the cells. Snodgrass records no longitudinal muscle in the small intestinal of the honeybee, but in the yellow jacket there are two muscular layers, an inner layer of circular muscles and an outer one of longitudinal muscles.

The Rectal Valve. This valve is marked by an increase in the number of circular muscles and by a change in shape of the epithelial cells, which become elongate and lie in a double layer. (Pl. III, Fig. 4.)

The Rectum. The longitudinal muscle along the remaining portion of the tract seems to be discontinuous. It is present as an outer layer of muscle along just the anterior portion of the rectum. There is no evidence of a longitudinal muscle again until the tract approaches the anus. The circular muscle exists as a single layer around most of the rectum and then occurs in several layers near the anus. Unlike the rectal pads in *Apis* and the bumblebee (10) there is no lumen. (Pl. III, Figs. 2 and 4.) The cells of the outer layer of epithelial cells are cuboidal and devoid of intima and lie adjacent to the cells of the internal layer, which are large and elongate and possess a heavy chitinous intima. The function of these rectal pads is not definitely known. They may be glands that secrete a substance into the rectum, or they may be structures that draw water from the execrement.

LITERATURE CITED

(1) **Bordas, L.** 1894. Appareil glandulaire des Hymenopteres. 1re These. L'Academie de Medecine. Paris. 362 pp., 11 pls.
(2) **Butt, F. H.** 1934. The origin of the peritrophic membrane in *Sciara* and the honey bee. Psyche 41: 51–56. 1 pl., 4 figs.
(3) **Cambell, F. L.** 1929. The detection and estimation of insect chitin. Ann. Ent. Soc. Amer. 22: 401–426. 1 fig.
(4) **Duncan, C. D.** 1939. A contribution to the biology of North American Vespine Wasps. Stanford University Press. Stanford Univ., Calif. 272 pp., 54 pls., 255 figs.
(5) **Green, T. L.** 1931. The alimentary canal in the common wasp, (*Vespa vulgaris*). Proc. Zool. Soc. London, 1931. Pp. 1041–1065. 14 figs., 1 pl.
(6) **Kennedy, C. H.** 1932. Methods for the study of the internal anatomy of insects. Mimeo. H. L. Hedrick, Columbus, Ohio.
(7) **Nelson, J. A.** 1915. The embryology of the honey bee. Princeton Univ. Press. Princeton N. J. 282 pp., 95 text-figs., 6 pls., 15 figs.
(8) **Snodgrass, R. E.** 1925. Anatomy and physiology of the honeybee. McGraw-Hill Book Co., New York. 327 pp., 108 figs.
(9) **Snodgrass, R. E.** 1935. Principles of insect morphology. McGraw-Hill Book Co., New York. 667 pp., 319 figs.
(10) **Swingle, M. C.** 1927. The alimentary tract of the common bumblebee. Ohio Jour. Sci., 27: 219–231. 3 pls., 18 figs.
(11) **Wigglesworth, V. B.** 1930. Formation of the peritrophic membrane. Quart. Jour. Micro. Sci., 73: 593–616.
(12) **Wigglesworth, V. B.** 1939. The principles of insect physiology. E. P. Dutton & Co., New York. 434 pp., 316 figs.

EXPLANATION OF PLATES

Plate I

Fig. 1. Dorsal view of alimentary tract, showing relative size and position of parts. Malpighian tubules shortened, showing only point of origin.
Fig. 2. Longitudinal section through a Malpighian tubule.
Fig. 3. Cross section through the crop.
Fig. 4. Cross section through the proventriculus.
Fig. 5. Cross section through the pyloric valve. (Semi-diagrammatic.)
Fig. 6. Cross section through a Malpighian tubule.

Plate II

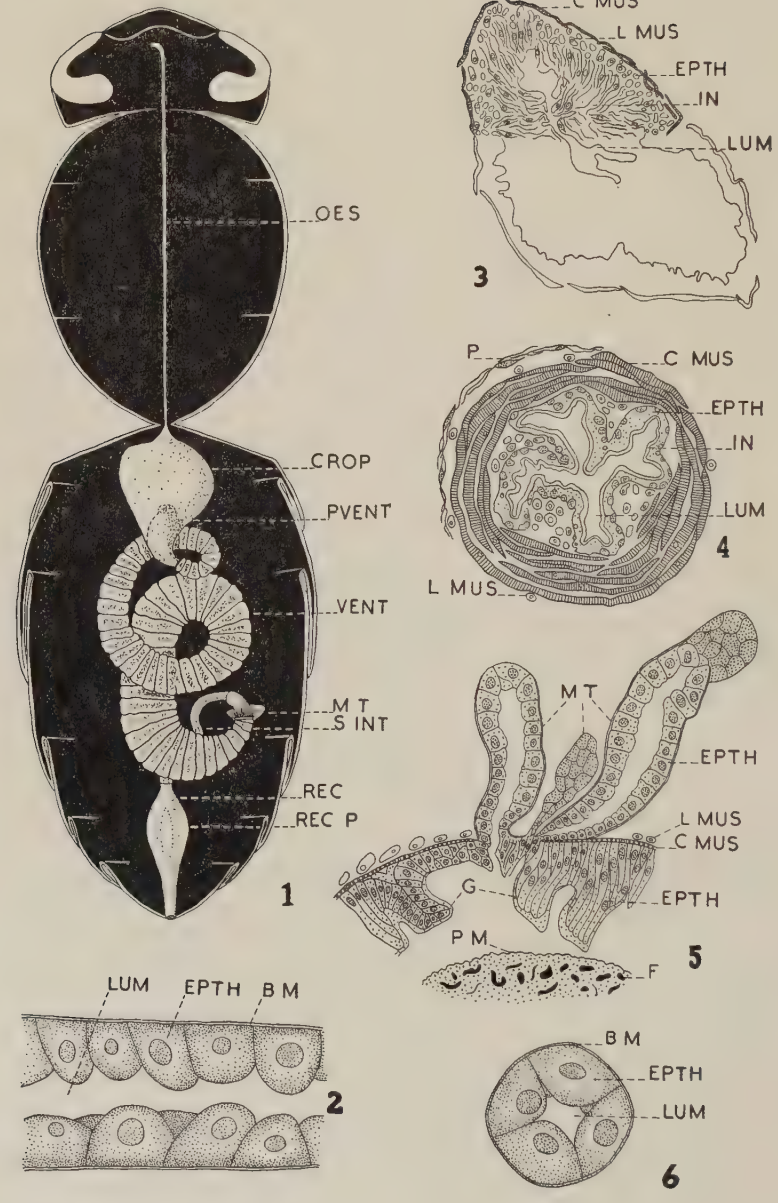
Fig. 1. Alimentary tract removed and straightened, showing relative dimensions of parts.
Fig. 2. Longitudinal section through the oesophageal valve, the valve considerably shortened. (Semi-diagrammatic.)
Fig. 3. Portion of cross section through the ventriculus, showing formation of the peritrophic membrane.

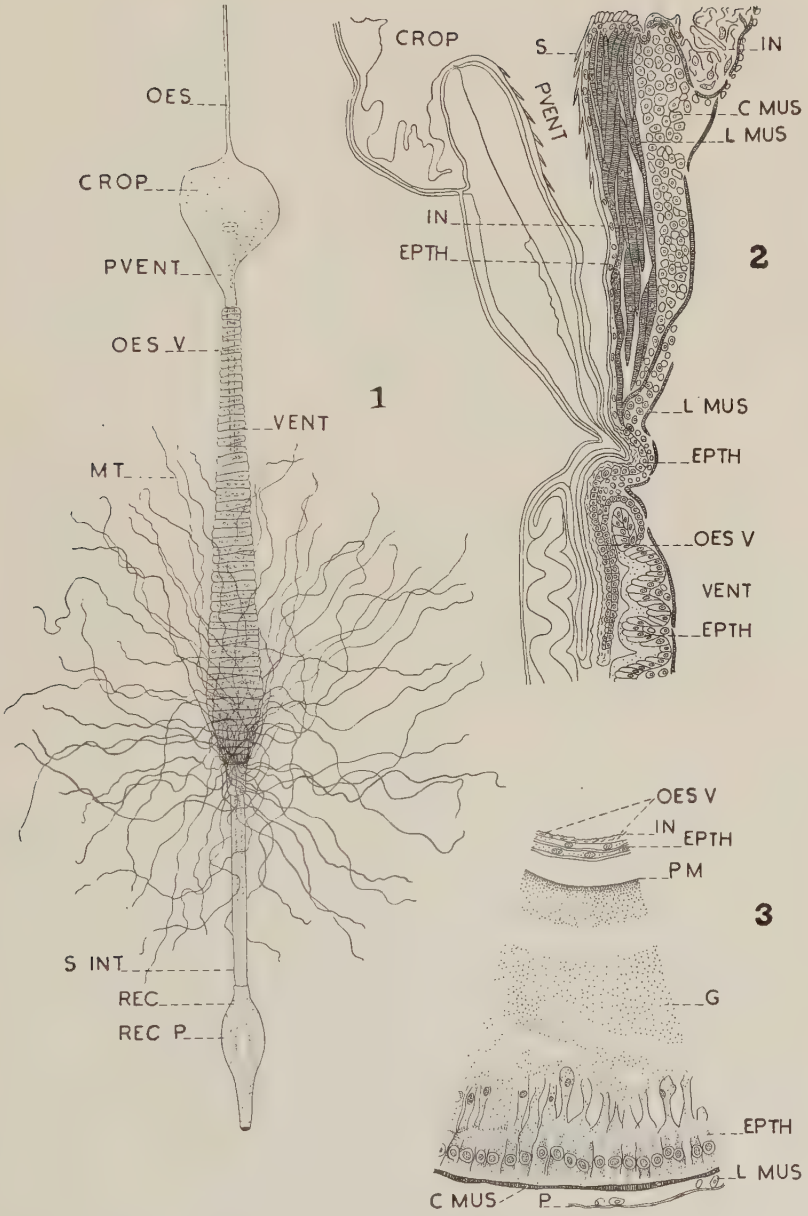
Plate III

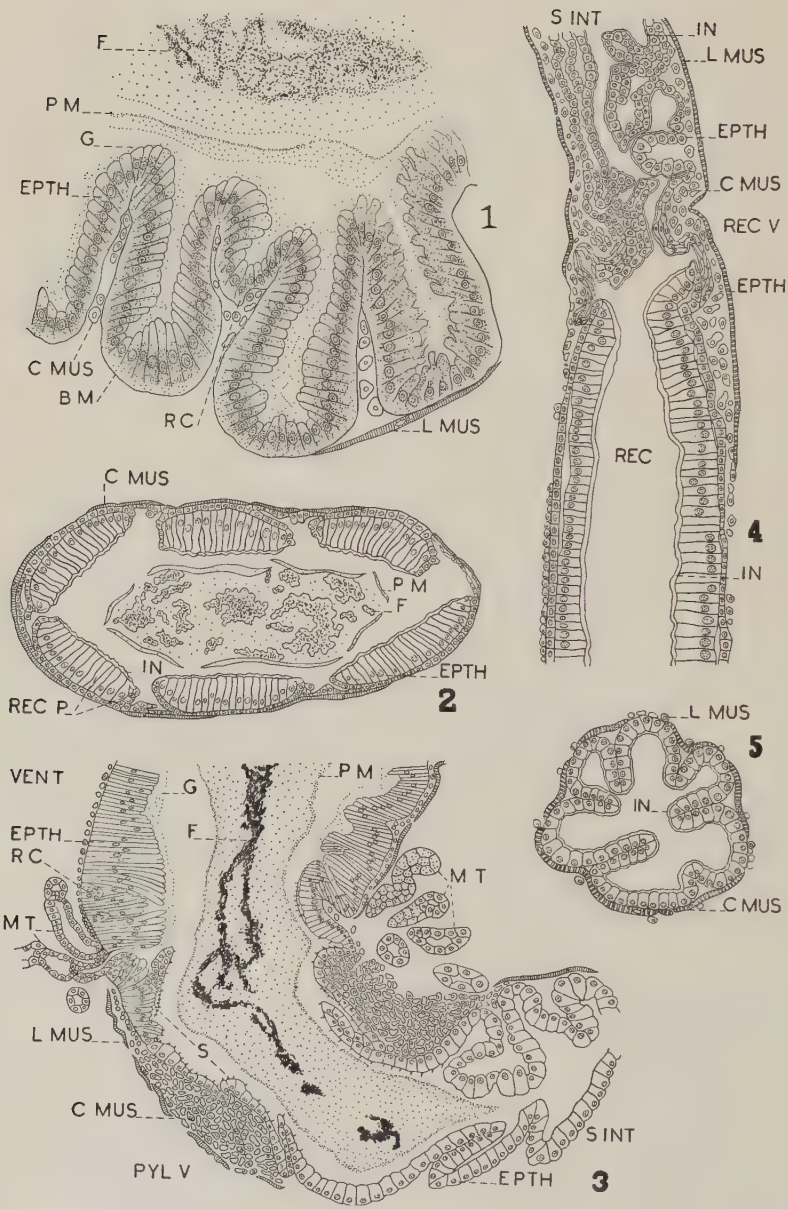
Fig. 1. Longitudinal section through portion of the ventriculus.
Fig. 2. Cross section through mid-section of the rectum.
Fig. 3. Longitudinal section through the pyloric valve.
Fig. 4. Longitudinal section through the rectal valve.
Fig. 5. Cross section through the small intestine.

KEY TO THE SYMBOLS USED WITH THE FIGURES

B M—Basement membrane.
C MUS—Circular muscle.
EPTH—Epithelium.
F—Food particles.
G—Secretion of epithelium.
IN—Intima.
L MUS—Longitudinal muscle.
LUM—Lumen.
M T—Malpighian tubule.
OES—Oesophagus.
OES V—Oesophageal valve.
P—Peritoneum.
P M—Peritrophic membrane.
PVENT—Proventriculus.
PYL V—Pyloric valve.
R C—Regenerative cell.
REC—Rectum.
REC P—Rectal pad.
S—Spine.
S INT—Small intestine.
VENT—Ventriculus.


OES
CROP
PVENT
VENT
M T
S INT
REC
REC P
1
C MUS
L MUS
EPTH
IN
LUM
3
P
C MUS
EPTH
IN
LUM
4
L MUS
M T
EPTH
L MUS
C MUS
G
EPTH
P M
F
5
LUM
EPTH
B M
2
B M
EPTH
LUM
6


OES
CROP
PVENT
OES V
VENT
MT
S INT
REC
REC P
1
CROP
S
IN
PVENT
C MUS
L MUS
IN
EPTH
2
L MUS
EPTH
OES V
VENT
EPTH
OES V
IN
EPTH
PM
3
G
EPTH
L MUS
C MUS
P


F
P M
G
EPTH
1
C MUS
B M
R C
L MUS
S INT
IN
L MUS
EPTH
C MUS
REC V
EPTH
REC
4
IN
C MUS
P M
F
IN
EPTH
REC P
2
L MUS
5
IN
C MUS
VENT
G
P M
EPTH
F
R C
M T
M T
L MUS
S
C MUS
S INT
PYL V
EPTH
3

QUANTITATIVE DETERMINATION OF RHYTHMICITY IN ORGANISMS

ORLANDO PARK,
Northwestern University

Within recent years increasing attention has been paid to the analysis of periodic activity of animals under controlled conditions by ecologists, and to periodic rhythms within the organism by physiologists. This general subject has been recently discussed (1), but there are several aspects of general organismal activity which need additional emphasis.

It is quite clear that there are several categories of activity; second, that this activity pattern of a species is complex and specific; third, that the activity pattern can be modified by the environment. The last two generalizations are obvious, but the first should be examined. Periodic environments are in general inhabited by species having periodic activity patterns, while certain social species and those species living in relatively constant environments tend to have an arhythmic activity pattern. The various permutations of organismal activity may be arranged within the following outline of diel patterns:

I. Rhythmic Activity (Periodic Activity).
An activity pattern in which the fundamental characteristics of the activity-inactivity curve for a species population recur through successive day-nights (diel periods).

1. *Environmental Type* (Exogenous Type).
Periodic activity in which the pattern is directly induced by, and controlled by, the periodic environmental factors.

2. *Endogenous Type.*
Periodic activity in which the pattern is resident in the protoplasm, therefore more deeply-seated, and not directly induced by, but may be modified by, the environment.

a. *Habitual Activity.*
Endogenous activity which is the result of past experience, or induction in the individual, and consequently indirectly induced by the environment.

b. *Inherent Activity* (Instinctive Activity ?).
Endogenous activity which is a part of the species heredity.

3. *Composite Type.*
Periodic activity in which the pattern is in part exogenous, and in part endogenous.

II. Arhythmic Activity (Aperiodic Activity).

Activity of a species population, the individuals of which do not exhibit an average periodic pattern, but in which each individual exhibits a varying activity through successive day-nights.

The experimental findings for these several categories have been sorted in the discussion alluded to. Obviously such an outline is an expedient scheme, as well as a logical one. It is designed for laboratory analysis, since the proper placing of a pattern cannot be definitely made on uncontrolled data. For example, the overwhelming majority of animals has a periodic activity, but whether a particular individual has its pattern induced and controlled by the environment, or has an endogenous pattern, can be discovered only by placing the animal in a constant environment. Under constant conditions, if the pattern persists the activity may be habitual or inherent, and these two types can be separated with certainty only by breeding the species under constant conditions. It is also obvious that objective recording apparatus must be employed, preferably electrical apparatus, utilizing either a continuous record, or if a drum is used then its diameter and speed adjusted so that activity peaks will not obscure each other. Complete control is desirable, as well as non-disturbance of the animal through the changing of records, replenishing food and water supplies, noise, *et cetera*. The possibility of indirect tutelage and learning or induction of various kinds, as well as the operation of little known physical influences should be realized, and where possible guarded against. I am inclined to suggest that nothing more than a bare start has been made in the method of attack on the problem, or in the accumulation of critical information.

To implement the assignment of activity pattern, the following mathematical suggestion is made:

Let: A. *Amplitude* of a twenty-four hour (diel) cycle.
F. *Frequency* of a twenty-four hour (diel) cycle.
A. I. *Activity Index.*
T. A given twenty-four hour trial.
K. Trials run under constant environmental conditions.
R. Trials run under the normal fluctuating environmental conditions.
a. *Actant.* An actant is the percentage for any given hour of the total activity for that diel cycle, the total activity for the cycle equaling 100%.

d. *Diant.* A diurnal actant.
n. *Noctant.* A nocturnal actant.
v. *Vocant.* An actant which is measured by vocalization, stridulation or other sound production, rather than by movements of the animal.
p. *Populant.* The average actant of a population.
N. Average of the noctant gain over 50% activity for a diel cycle.
D. Average of the diant gain over 50% activity for a diel cycle.
0^n Number of trials out of a given experiment (ten trials suggested) which show a nocturnal gain.
0^d Number of trials out of a given experiment (ten trials suggested) which show a diurnal gain.

The following figure (Fig. 1) gives graphical expression to some of these terms which have been suggested to (1) facilitate

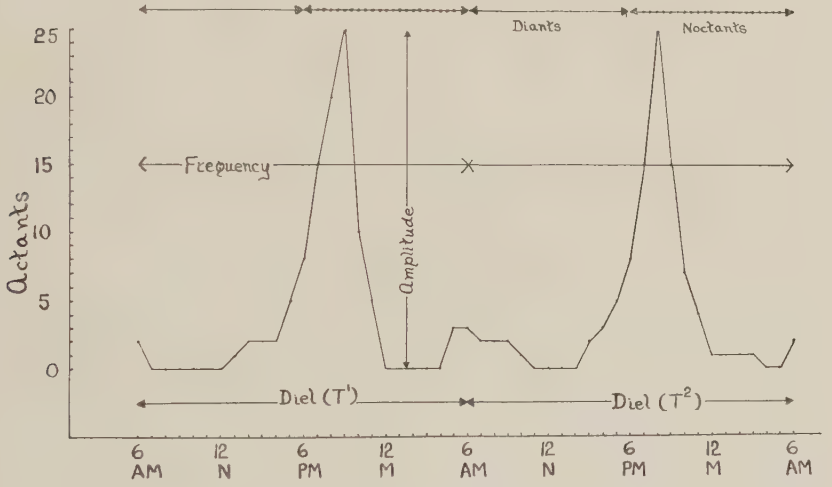


Fig. 1. Structure of a Typical Activity-inactivity Curve, Over Two Diel Periods, for a Hypothetical Nocturnal Animal.

the formulation of a mathematical approach to the study of diel periodicity, and (2) bring order to a rapidly expanding research field. A tentative formulation follows:

$$\frac{N\,0^n}{D\,0^d} = A.I.\left(\text{at } T^{10\ (R \text{ or } K)}\right)$$

I. Where individual activity is being measured by recorders in the field, or under normal fluctuating environmental factors, the application of this formula to the activity units collected will serve to separate those animals having a periodic activity

from those having arhythmic activity. Where population activity is being studied special criteria will be employed which, when stated as populants, can be directly compared with recorded activity.

II. Where activity is being studied in the laboratory under "constant" conditions, the same formula will serve to (1) separate arhythmic from endogenous activity, where the latter is synchronized with the diel cycle, e. g., on a twenty-four hour frequency; (2) estimate quantitatively the degree of nocturnal or diurnal endogenosity of such synchronized activity; (3) measure loss of amplitude in successive diels if the actants are analyzed in successive samples where synchronized periodic activity is involved.

III. To separate habitual from inherent endogenosity, the animals must be bred in the constant experimental conditions, shielding the new generation from contact or tutelage of parent or parents, and application of the formula. Under these conditions, periodic activity in the generation thus born will be inherent activity in the strict sense. This is difficult to accomplish but oviparous invertebrates would appear to be the best research material for such an attack.

This formula will not anlayze unsynchronized activity rhythms, e. g., 25 hour periodism, *et cetera*, since in such a species, the cycle would shift through time on successive diels. Under such conditions, the first sample might show an endogenous diurnality, but a larger sample, involving fifty trials, might show an arhythmic activity index although the rhythm would be intact. This would be a consequence of the shift in noctant-diant ratio.

In addition to rhythms not on a twenty-four hour frequency, there is also the possibility of rhythm with a varying frequency. In both such possibilities a much more complex formulation will have to be applied.

For activity patterns synchronized on the diel rhythm, the simple formula will analyze the activity curve on a quantitative basis in terms of actants but to employ the formula, night and day must be definitely limited since the length of day and night varies regularly with latitude and time of year. There are numerous ways in which day and night can be arbitrarily fixed, depending upon the type of investigation being pursued. For example, nocturnal activity may be said to be the activity (1)

between sunset and sunrise, either on an astronomical basis or on an arbitrary photometric standard of so many foot-candles, at a given latitude and time of year, in which case this designation of nocturnal may have to be factored, or (2) average sunset to average sunrise at a specific latitude and time of year, or (3) for experimental purposes some arbitrary designation, as from 6:00 P. M. to 6:00 A. M., *et cetera*. Similarly diurnal activity would then be the converse of any one form of designation adopted for nocturnal activity.

In the second place, ten complete diel periods are given in the above formula, merely as a suggestion. Ten trials may be sufficient, or a thousand trials may be necessary. Experience in frequent sampling of the data will demonstrate how many trials are needed to give an accurate activity index of a species activity pattern.

The terms N and D of the formula must be understood. If ten diels are used, the actants for each diel are determined and then, using the standard day and night decided upon, the actants are separated into diants and noctants respectively. Obviously, in an arhythmic species the diants and noctants tend to equal each other, in a nocturnal species the noctants are many and diants few, in a diurnal species the diants are many and the noctants few. N, the average gain in nocturnality, is the average of the noctants of the ten trials over 50% activity. Thus a species with a theroetical 100% nocturnality, would have a net average of 50%, while an animal with 80% nocturnality, would have a net average of 20%, etc. D is formed in the same way as N, using the diants instead of noctants.

It is necessary to express our activity data in some such way as per cent. This is due to increasing investigation on different kinds of animals, using many different kinds of recorders. Thus data are available in the form of vocalization-rate, distance moved per time unit, number of movements per time unit, various activity units, and so on, so that only a percentage figure, like the actant or its variants, is suitable for direct comparison. To further clarify the method, several hypothetical examples are given:

EXAMPLE 1. Animal exhibiting 100% nocturnal endogenosity. 10 diels with 50% noctant gain each (maximum):

$$\frac{50 \times 10}{0 \times 0} = \text{A. I. } \infty$$

Mathematically, this is the upper limit of the activity index, and to my knowledge has not yet been demonstrated for any species, although many species have a high A. I.

EXAMPLE 2. Animal exhibiting no periodicity, e. g. arhythmic. 10 diels with 5 of them having a 50% noctant gain, and 5 of them having a 50% diant gain, or some similar combination in which no net gain could be demonstrated for the experiment.

$$\frac{5 \times 50}{5 \times 50} = \text{A. I. of 1.}$$

Where the A. I. approaches unity, arhythmicity is demonstrated. All arhythmic species under constant conditions show such a low activity index.

EXAMPLE 3. Animal exhibiting 100% diurnal endogenosity. 10 diels with 50% diant gain each (maximum) :

$$\frac{0 \times 0}{50 \times 10} = \text{A. I. of 0}$$

Mathematically, this is the lower limit of the activity index, the latter having a spread from ∞ to 0, with perfect arhythmicity at the median point.

Once the absence of periodicity, or its presence is known, then by shift from constant conditions to conditions involving one varying influence at a time, the degree of exogenosity and endogenosity may be determined, etc.

The following table (Table I) gives several A. I. which have been determined experimentally within recent years:

TABLE I

EXAMPLE OF ACTIVITY INDEX

ANIMAL	CATEGORY OF ADULT	A. I.	CALCULATED FROM
Cambarus pellucidus	Arhythmic	3.4	(2)
Tamais striatus griseus	Endogenous diurnal	0.0102	(3)
Spirobolus marginatus	Endogenous nocturnal	960.0	(4)

From this table we see three activity indices, well spread out over the range of the scale. The chipmunk A. I. is for the first ten trials only, since the rhythm tends to shift rapidly

under constant conditions of darkness, temperature and humidity. This may indicate a high degree of habitual endogenosity in this species, but the work on the animal has just begun. The cave crayfish A. I. is based on ample data, and the A. I. for the milliped is within the expected range for the species.

SUMMARY

A discussion of the quantitative estimation of organismal activity is given, and certain mathematical suggestions are made to implement the quantitative study of rhythmicity.

LITERATURE CITED

(1) **Park, Orlando.** 1940. Nocturnalism—the development of a problem. Ecol. Mono., 10: 485–536.
(2) **Park, Orlando, Roberts, T. W., and Harris, S. J.** 1941. Studies on nocturnal ecology, VIII. Preliminary analysis of activity of the cave crayfish, *Cambarus pellucidus*. Am. Nat. (In press.)
(3) **Park, Orlando and Woods, L. P.** 1940. A modified Hemmingsen-Krarup mammalian activity recorder. Proc. Soc. Exp. Biol. Med., 43: 366–370.
(4) **Park, Orlando.** 1935. Studies in nocturnal ecology, III. Recording apparatus and further analysis of rhythm. Ecology, 16: 152–163.

Entomophagous Insects

Occasionally a biologist finds a book in his field of major interest which proves to be exactly what he needs in graduate teaching and research. This has been this reviewer's reaction to Mr. Clausen's new book on Entomophagous Insects.

The book is a remarkable one volume compilation of the greatly scattered knowledge and detailed information on entomophagous insects found in the world literature. In addition to the compiled information the author has introduced a great amount of original data derived from his wide experience with parasitoid species. The book does not follow the usual presentation of information in chapters but treats the subject matter from the viewpoint of insect orders and families. This arrangement is highly desirable for an investigator or teacher.

The author emphasizes the importance of parasitoid species over predacious forms by the amount of space allotted to the respective groups. Briefly stated the Hymenoptera (almost exclusively parasitoid families) covers 342 pages and the Diptera (largely parasitoid information) 140 pages. A fascinating compilation of the known information about Strepsiptera covers 25 pages. The remaining 100 pages includes the information on the following orders, chiefly predacious: Lepidoptera, Coleoptera, Hemiptera, Thysanoptera, Trichoptera, Mecoptera, Plecoptera, Neuroptera, Odonata, Corrodentia, Orthoptera, Dermaptera, and Thysanura.

Throughout the discussion of the parasitoid groups the author summarizes the significant facts about several species in each family. He also has incorporated many excellent drawings of immature stages stressing their detailed morphological characteristics and habits. At the end of the book over 1000 references to the world literature on entomophagous insects may be found.

Mr. Causen is to be congratulated on his splendid presentation of the existing knowledge on entomophagous insects, particularly parasitoid species. Biological control entomologists may now possess an authoritative and useful storeroom of facts on entomophagous insects.—*Alvah Peterson.*

Entomophagous Insects, by C. P. Clausen. x+688 pp.; 257 figures, Biblio. New York, McGraw-Hill Book Co., Inc. 1940. $7.00.

PRESENCE OF THE LIGAMENTUM BOTALLI IN THE GOLDEN EAGLE AQUILA CHRYSAËTOS (L.), THE RED-TAILED HAWK BUTEO BOREALIS BOREALIS (GMELIN), AND THE COMMON PIGEON COLUMBA LIVIA (L.)

FRED H. GLENNY,
Department of Biology,
University of Akron

INTRODUCTION

During the preparation of a series of studies on the main arteries in the region of the heart of birds (3), the writer had the opportunity to observe a ligament to which no direct reference had been made in the better known references on avian morphology.

As the writer has already noted in other discussions on avian morphology (2 and 3), little work of a serious nature has been undertaken in the study of bird arteries since the close of the 19th century.

Recently, during a study of the arteries of the Golden Eagle (*Aquila chrysaëtos*), the Red-tailed Hawk (*Buteo borealis borealis*), and the common pigeon (*Columba livia*), it was the writer's good fortune to observe a peculiar ligamentous structure lying along the ventral surface of the right 4th aortic arch. Careful removal of the fascia which surrounded the aortic arch revealed this structure to be a separate ligament and not part of the aortic arch.

OBSERVATIONS

An unrecognized ligament was found to be attached to the aortic arch just anterior to the junction of the ligamentous left 4th aortic arch and the dorsal aorta in each of the three species studied. The ligament passed anteriorly along the ventral surface of the right 4th aortic arch until it reached a point near the right pulmonary artery—just posterior to the bend of the right 4th aortic arch and the subclavian artery. The ligament formed an anterior attachment with the pulmonary artery just before it entered the lung.

A ligamentous vestige of the left 4th aortic arch was located in the normal position in each of the three species of birds.

The ligament of *Aquila* possessed a minute lumen from which a small amount of blood was obtained. It appeared to have served as a functional blood vessel during the late embryonic stages in this species. In contrast to this condition, the ligament of both *Columba* and *Buteo* entirely lacked any evidence of a lumen and no blood could be obtained.

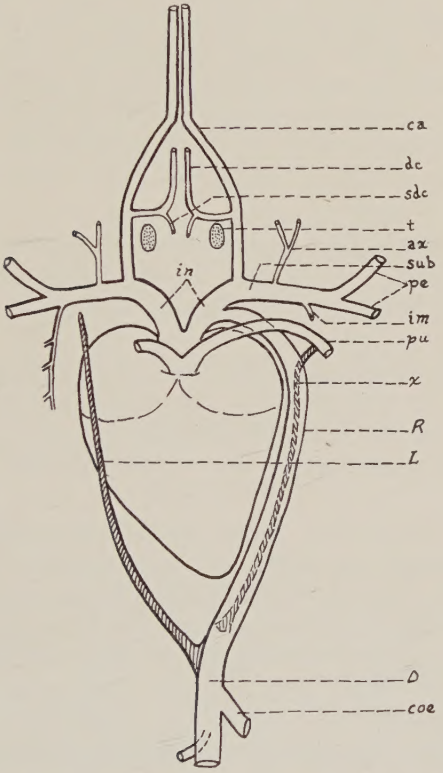


Diagram of the main arteries in the region of the heart of *Columba livia*. Dorsal view.

ax, Axillary artery; ca, internal carotid artery; coe, coeliac artery; dc, external carotid artery; im, internal mammary artery; L, ligamentous vestige of the 4th left aortic arch; D, Dorsal aorta; pe, pectoral artery; pu, Pulmonary artery; R, 4th right aortic arch; sdc, superficial branch of the external carotid artery; sub, Subclavian artery; t, Thyroid gland; x, Ligamentum Botalli; in, Innominate artery.

DISCUSSION

All of the commoner references to the 6th aortic arches of birds indicated that the primitive or embryonic connections with the dorsal aorta were completely atrophied during the late

embryonic development of the bird,[1] and especially after the connections with the lungs had been established.[2] This is not entirely the case, as has been shown in the above evidence.

Since the posterior end of the ligament was inserted in the dorsal aorta at about the position expected in the embryo, and since the anterior attachment was made with the pulmonary artery, it was finally concluded that this ligament was a vestige of the embryonic 6th aortic arch. Once this had been established, it was a simple matter to recognize the ligament as a vestige of the *ductus arteriosus* or *ductus Botalli* (5 and 6). The *ductus Botalli* is reported in the Urodeles and the embryonic stages of the amniota. Among the higher vertebrates, including mammals, a ligamentous vestige of the ductus arteriosus has been reported (4 and 5).

The writer could find no reference to the occurrence of this ligament in birds. From the above evidence, however, its occurrence and persistence in certain species of birds has been established.

It is the writer's opinion that this ligament should be referred to as the *Ligamentum Botalli* since it has its origin in the *ductus arteriosus* or *ductus Botalli.*

CONCLUSIONS

It may be concluded, from the above evidence, that this ligament is a persistent vestige of the embryonic 6th aortic arch. Furthermore, it may be concluded that, although this structure is reported from but three species of birds at the present time, the vestigeal portion of the 6th aortic arch may be found in still other species of birds, and may be anticipated in still other species of Raptores.

It is the writer's opinion that the persistence of this ligament represents a primitive avian condition, and helps to bear out the writer's contention in a previous paper (3) that the arrangements of the arteries in the region of the heart may later be used to show certain fundamental natural relationships among the various families of birds.

---

[1] "Der dorsale Abschnitt des 6. Bogens (des Pulmonalis bogens) fällt beiderseits völligem Schwund anheim, nachden er kurze Zeit während des Embryonallebens als Ductus Botalli die Lungen arterie mit der dorsalen Aorta verbunden hat." (6).

[2] "With the development of lungs a pair of pulmonary arteries are developed from the 6th pair of arches on the ventral side of the pharynx. These grow back into the lungs, while the rest of the arch, dorsal to their origin, becomes reduced to a small vessel, the *Ductus arteriosus* (d. Botallii) in some Urodeles, and persists occasionally vestigially in higher vertebrates. Elsewhere it entirely disappears." (5).

SUMMARY

1. The *Ligamentum botalli* was observed in *Aquila chrysaëtos*, *Buteo borealis borealis*, and *Columba livia*.

2. The *Ligamentum Botalli* represents the vestigal portion of the embryonic 6th aortic arch which forms the attachment to the radix aorta.

3. The ligament was attached posteriorly to the radix aorta and anteriorly to the pulmonary artery.

4. Fundamental natural relationships may be established by the presence of such vestigeal structures in the various species of birds, at least within the various orders and families of birds.

REFERENCES

(1) **Beddard, Frank E.** 1898. *The Structure and Classification of Birds.* London, Longmans, Green & Co.
(2) **Glenny, Fred H.** 1939. *An Anomalous Artery in the Kingfisher (Ceryle alcyon).* The Ohio Journal of Science, 39: 94–96.
(3) ———. 1940. *A Systematic Study of the Main Arteries in the Region of the Heart—Aves—Part I.* The Anatomical Record, 76: 371–380.
(4) **Heilmann, Gerhard.** 1927. *The Origin of Birds.* New York, D. Appleton and Company.
(5) **Kingsley, J. S.** 1926. *Outlines of Comparative Anatomy of Vertebrates.* Philadelphia, P. Blakiston's Son & Co.
(6) **Stresemann, E.** 1927–32. Aves—*Handbuch der Zoologie*, 73: 206.

Laboratory Directions

It is an almost impossible task for one person to evaluate fairly a laboratory manual in general biology. It is unusual to find two teachers who agree on the content of such a manual, to say nothing of the arrangement and mode of presenting the material.

The manual before us is a loose-leaf assembly divided into three sections: I. Botany, II. Invertebrate Zoology, III. Vertebrate Zoology. The emphasis of the writers is apparently upon morphology. There are two preliminary exercises designed to familiarize the student with the microscope and its use.

Part I. encompasses the Plant Kingdom with twelve exercises covering Thallophyta (8 exercises), Bryophyta (2 exercises), Pterydophyta, and Spermaphyta. The "type-form" is used in the study of each group. Part II. contains fifteen exercises, three of which are devoted to Protozoa, the remainder to Porifera, Coelenterata, mitosis, Platyhelminthes (3 exercises), Nemathelminthes, Annelida, Mollusca, Arthropoda and Echinodermata. Part III. includes eighten exercises, some of which cover as much as eleven pages. The Protochordates are allotted three exercises, the remaining fifteen, one each to Petromyzon, Squalus, Perch, fish scales, caudal fins, Necturus, frog, turtle, lizard, Pigeon, fetal pig, heart kidney, eye, brain and cranial nerves.

Careful dissection by the student and much drawing are essential in using this guide. Such a manual presumably would be suitable for a course in Comparative Anatomy although it is not in accord with the modern conception of a "generalized" course in Biology.—*Paul E. Schaefer.*

Laboratory Manual of General Biology, by John G. Arnold, Jr., and Timothy L. Duggan. Fourth Edition, 275 pages. St. Louis. C. V. Mosby Company, 1940.

BOOK NOTICES

A Short Course in Zoology

What shall be the content of a one-semester course in Zoology? Probably no two teachers would include the same material. Certain type animals and a group of general principles would be common to both but each individual would emphasize certain features which the other had minimized or omitted. These facts make the selection of materials for such a course especially difficult.

Dr. Potter of Texas A. & M. presents his concept of what a one-semester course should include but has so organized his material that other teachers may rearrange the order or omit whole chapters if it is so desired.

The bullfrog and the rat are discussed in some detail as representatives of the vertebrates. Euglena, Amoeba and Paramecium were chosen as types of Protozoa. Hydra, Planaria, Ascaris, Earthworm, Starfish, Freshwater Mussel, Crayfish and Locust typify the invertebrates. Several general chapters such as Protoplasm and the Cell, Metazoan Organization, Chordates in General, Physiology, Endocrine Glands and their Functions, Sexual Reproduction and Development of the Individual, Genetics and Eugenics, and several others greatly broaden the scope of the book.

The importance of ecology is recognized by the inclusion of three specific chapters, Animal Parasitism, The Animal and its Environment, Animal Distribution. These chapters are well done save for the tendency, common to ecologists, to obscure meaning by the use of technical terms unnecessary to the general student.

The closing chapter, "The Theory of Evolution," panorams the topic, but lists a few more extensive references at its close as is the practice with each preceding chapter.

An attempt to pack the utmost into such restricted space makes condensation and generalization essential, which in turn permits inadvertent inaccuracy, exemplified by the discussion of metabolism and growth on page 43. The text is copiously illustrated. Any one interested in a one-semester text will do well to examine this book.—*Paul E. Schaefer.*

Essentials of Zoology, by George Edwin Potter. 526 pages. St. Louis, C. V. Mosby Co., 1940. $3.75.

Plant Microtechnique

This contribution will fulfill the needs of most technicians dealing with plant tissues. Although extensive, it is not encyclopedic and is easily read. Many of the more important microtechnical methods are reviewed and in addition numerous previously unpublished methods are included. Chapters with critical evaluations are found dealing with the more familiar problems of killing and fixation, dehydration, embedding, sectioning and staining. Other chapters present material on whole mounts, glycerine, celloidin, paraffin, cytological, smear, and microchemical methods. The chapter on smear methods is timely, up to date, and much more extensive than is contained in any other text known to the writer. The chapter on celloidin is quite brief. The part on microchemical methods should be of considerable aid to histologists. However, many of the tests are not given with much detail. Some microchemists will not agree that thick sections (up to 50 microns) are more satisfactory to work with than thin sections. A short chapter on sources of materials will be of value to many students.

Over half the volume is devoted to chapters on the various plant phyla. Much valuable information is given on the time and where to collect, culturing, and preservation of specimens.

The book is illustrated with a frontispiece and 110 text figures. Most of these are photomicrographs. The bibliography consists of 256 references. An adequate index is included. In the writer's opinion, this is the best book so far produced on the subject of plant microtechnique.—*Glenn W. Blaydes.*

Plant Microtechnique, by Donald Alexander Johansen. xi+523 pp. New York, McGraw-Hill Book Company, Inc. 1940. $4.50.